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MINERAL RESOURCES OF CENTRAL ITALY

W. P. JERVIS, F. G. S.

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MINERAL RESOURCES

OF

CENTRAL ITALY.

GENERAL VIEW OF THE MARBLE MOUNTAINS OF CARRARA, TAKEN FROM AVENZA. C. POINGDESTRE, *pinx.*

INTERNATIONAL EXHIBITION, 1862.

THE MINERAL RESOURCES

OF

CENTRAL ITALY;

INCLUDING A DESCRIPTION OF THE

MINES AND MARBLE QUARRIES.

By W. P. JERVIS, F.G.S.,
ASSISTANT-GENERAL TO THE ITALIAN SPECIAL COMMISSIONERS FOR THE EXHIBITION.

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PREFACE.

In publishing the present sketch of the Mineral Resources of Italy, I feel it necessary to give some explanation of the motives which have induced me to appear before the public.

Having been delegated by the Royal Italian Commission to travel through the Central provinces of the Kingdom, in order to aid in procuring products to be forwarded to the International Exhibition, I took the opportunity of adding to the scattered notices on the subject which I had previously presented, at various times, to the Society of Arts of London, and which were published in their *Journal*.

The Royal Commission subsequently did me the honour to appoint me Assistant-General to the Special Commissioners from Italy at the International Exhibition. I desire to contribute the result of my labours, which I have published in English for the sake of the British Public; and I entertain a sincere hope that the sympathy shown by the British nation for regenerated Italy, and the friendly feeling subsisting between the two countries, may be daily strengthened by the commercial intercourse which has been promoted in so praiseworthy and energetic a manner by the Royal Italian Commission.

MAP
SHOWING THE RELATIVE POSITIONS OF THE
QUARRIES AND MINES
AT
CARRARA, SERAVEZZA, AND MASSA,
And indicating a System of Tramroads proposed by the Author in 1859.
SCALE OF ITALIAN OR GEOGRAPHICAL MILES.
TRAMROADS
RAILWAY
CARRARA
STATION
RIVER CARRION
(FROM SPEZIA)
STATION
AVENZA
DEPOT FOR CARRARA MARBLES
VALTON PIER
TUNNEL
EXTENDED
COPPOLI
MASSA CARRARA
STATION
MONTIGNOSO
RIVER FRIGIDO
TUSCAN SEA
LINE OF RAILWAY FROM GENOA TO PISA
FORT
RIVER VERSIGLIA
FORT
PIETRASANTA
TO PISA
STATION
VAL DI CASTELLO LEAD MINE
MERCURY MINE
RIPA
QUERCETO
CORVAJA
BOTTINO LEAD MINE
SERAVEZZA
R. SERRA
OAZZANO
MONTE CARCHIO
MONTE ALTISSIMO
ARNI
ARNETOLA
MONTESELLA
FORNO
MONTE CORCHIA
PANIA DELLA CROCE
MERCURY MINE
EVIGLIANO
RETIGNANO
ROSINA
CARDOSO
SLATE QUARRIES
IRON MINE
MONTE FORATO
R. VEZZA
ODA
STAZZEMA
FARNOCCHIA
MTE. GABBERI
STA. ANNA LEAD MINE
MONTE MATANNA
TAMBURA LEAD MINE

REFERENCES TO MAP.

	NAME OF QUARRY.	QUALITY OF MARBLE.
1	Crestola	Statuary.
2	Mossa	Veined statuary.
3	Cavetta	Statuary.
4	Zampone	Statuary, *bardiglio.*
5	Poggio Silvestro	Statuary.
6	Betogli	Statuary.
7	Polvaccio	Statuary.
8	Carpevola and Finocchioso	Statuary, *paonazzo.*
9	Fossa degli Angioli	Ordinary and white marble.
10	Piastra	
11	Grotta Columbara	
12	Ravaccione	
13	Canal Bianco	Best ordinary.
14	Vallini	Ordinary and white marble.
15	Porcinacchia	Veined white, *bardiglio.*
16	Boccanaglia	Veined white, *bardiglio, paonazzo.*
17	Pescina	Veined white, *bardiglio, breccia.*
18	Calacatta	Statuary, veined white, *bardiglio.*
19	Canal Picinino	Veined white, *bardiglio.*
20	Valbona	Veined white.
21	Fantiscritti	Blueish ordinary.
22	Para	Fine veined white, procurable in enormous blocks.
23	Vara	
24	Belgia	Ordinary, veined *bardiglio.*
25	Fossa Cava	Veined white, ordinary.
26	Artana	*Bardiglio florito.*
27	Falcovaja	Statuary, ordinary.
28	Carchio	Statuary.
29	Polla	Statuary.
30	Rondone	*Mischio.*
31	Fontanaccia	*Bardiglio florito.*
32	Bottino lead mine	
33	Fornetto	White statuary.
34		Ordinary white.
35		Ordinary white.
36	Iron mine of buca alla vena	White marble, with veins of magnetic oxide of iron.
37	Carchio	White marble.
38	Canal D'Agiola	Ordinary, *bardiglio.*
39	La Costa	White.
40	Ceragiola	Common white.
41	Borrone	
42	Giardino	Best statuary, white ordinary.
43	Mont' Alto	*Bardiglio florito.*
44	Messette	
45	La Ratta	Slate quarry.
46	Pisciarotti	*Bardiglio florito.*
47	Solajo	Ordinary.
48	Pancola ferruginous mineral spring.	
49	Battaglino	Common white.
50	Piastrajo	*Mischio breccia.*
51	La Fontana	*Bardiglio florito.*
52	Sandstone quarry	*Pietra da scalini.*
53	Ditto, on Monte Volegno	
54	Capella	Ordinary.
55	Trambiserra	Common statuary, ordinary.
56	Vestito	*Mischio.*
57	Canal Bertone	Ordinary.
58	Poggio di Cipolo	
59	Vallini	
60	Campo Francesco	Statuary.
61	(No quarry as yet)	Brecciated limestone.
62	Sponda	Statuary.
63	Fondone	Statuary.
64	Lead vein on Monte Corchia.	
65	Campanice	Statuary.
66	Crocicchia	Statuary.
67	Monte Brugiana	Ordinary.
68	Nido del Corvo	Ordinary, sanguineous stalactite.
69	Al Ficale	*Mischio.*
70	Sordola	Spotted white.
71	Cerignano	White, black *bardiglio.*

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MINERAL RICHES OF CENTRAL ITALY.

CHAPTER I.

MARBLES.

ITALY is pre-eminently a marble-producing country. It is to this fact that we must, in a great measure, ascribe the splendour of her palaces and other public and private structures, in which not only the architectural ornaments, but frequently, as in the case of the cathedral at Milan, the entire edifice, is built of the finest marble. We almost instinctively associate the names of Greece or of Italy with statuary and other white marbles. The employment of this stone, so invaluable for ornamental work, from the ease with which it can be chiselled, dates from the remotest antiquity, for we find various works of art sculptured in it by the Greeks and the early inhabitants of Italy. Long before the foundation of Rome, the Etruscans possessed skilful sculptors, whose productions were afterwards held in high estimation by the Romans.

At the present day, few if any quarries are worked in Greece, so that almost all the statuary and white architectural marble employed throughout Europe and America is derived from the Apuan Alps.

From the circumstance of the marbles at Carrara (*Massa Carrara*) being found within a few miles of the ancient port of Luna, where it was employed in making the wall of the town, we may understand how the Romans should have turned their attention to it at an early period.

In the 16th century, the excavation of statuary marble was extended to Seravezza (*Lucca*), a town about ten miles east of Carrara, in the same range of mountains, while only within the last thirty years the marbles above the intermediate town of Massa (*Massa Carrara*) have been worked. These towns are situated at the foot of the mountains on the three little rivers, Carrione, Seravezza, and Frigido respectively. Each of these rivers flows through a deep valley it has cut for itself in the rock, numerous torrents on either side forming so many lateral valleys, so that the mountains have ridges often as sharp as the roof of a house. Two quarries of white marble also belong to the intermediate commune of Montignoso. On the north side of the Apuan Alps, behind Carrara and Seravezza, are the two communes of Vagli-sotto and Fivizzano, where the marbles are equally abundant, but have not yet been worked. At the entrance to the Gulf of Spezia there is a small indication of white marble in the territory of Sarzana. For the sake of simplicity, I will treat of the marble from these communes under separate heads, only including Montignoso under Massa. The information obtained respecting these sources of marble supply has involved an incredible amount of investigation, and being now for the first time presented in so detailed a manner, the reader will pardon me if I give an imperfect description of this highly important district.

After having described the marbles of the Apuan Alps, I will speak briefly of the marbles found near Spezia (*Genoa*), the Monti Pisani (*Pisa*), Campiglia (*Grosseto*), Elba (*Leghorn*), and the Montagnuola Senese (*Sienna*).

VIEW OF THE MARBLE QUARRIES AT CARRARA, TAKEN FROM CRESTOLA, AND LOOKING TOWARDS POLVACCIO. C. Poingdestre, pinx.

(From a painting in the possession of W. Walton, Esq., British Consul at Carrara.)

APUAN ALPS.

1. Carrara.

The magnificent white marbles which have been beautifully described by Stasio as the snow-white metal, *nivea metalla*, approach within a mile of Carrara, at the villages of Torano and Miseglia. Two spurs descend from Monte Sagro towards Carrara, suddenly terminating in the slopes above Torano; they enclose a deep narrow ravine, having a nearly straight course to its junction with the Carrione. The steep sides of this precipitous valley are entirely composed of white marble, and are quarried in their whole extent, according to the caprice of the respective proprietors, who mine here and there, as they consider the quality of the marble likely to be best. This is the valley whence most of the Carrara statuary marble is obtained, the names of the principal quarries producing it being in order as follows:—Crestola, Cavetta, Zampone, Poggio Silvestro, Betogli, Mossa, and Polvaccio. Berthier (*T. des essais*, tom. 1., p. 614) gives the analysis of a specimen of Carrara statuary marble, which is almost pure carbonate of lime, but without saying from what quarry it came:—

Lime.....	55·4	or, Carbonate of Lime..	98·1
Magnesia.....	0·4	Carbonate of Magnesia.....	0·9
Carbonic Acid.....	43·2		
Clay and Quartz...	1·0	Clay and Quartz ...	1·0
	100·0		100·0

I will refrain from giving any calculation of the thickness of the beds—which, however, is very considerable—as it is a difficult matter to trace them to their base, on account of the vast amount of *débris* lying about in every direction; planes of cleavage are also very numerous; oxide of iron has frequently penetrated into scarcely perceptible fissures, imparting to the marble around a dirty reddish-brown tinge, and rendering it unfit for use.

Numerous thin talcose beds occur here, accompanied by gypsum, sulphur, talc, pure white rhombohedral crystals of dolomite, and crystals of iron pyrites a sixteenth of an inch in the cube. By far the most interesting mineral is the quartz, which crystallises in the cavities of the marble, sometimes attaining one inch in length. It is perfectly limpid, whence the name *Carrara diamonds*. Some which I procured enclose foreign substances. I observed that in general they presented a very small point of attachment to the rock. These numerous associated minerals are eagerly sought for by the quarrymen, as they accompany the best statuary marbles. They are known as *Madri-macchie*. Some fissures thus filled up are several inches in thickness, others do not exceed one line in width, and contain a few scattered crystals of iron pyrites, firmly imbedded in the marble on one side. It is due, I consider, to the oxidation of these crystals that, on exposure to the air, the marble is discoloured and tinged reddish-brown.

As the statuary marble is the most highly crystallised, it is the most difficult to obtain free from flaws, though slightly veined white forms the mass of the mountains, and might be obtained to any extent desired, provided the market were good, and a better system of working introduced. The saccharoidal structure of the statuary marble is most perfect north-east of Cararra, and thence to the Altissimo; in other parts it is less so, until it is scarcely perceptible. I would ascribe the coarseness of the grain to slower cooling.

The slopes below the quarries are often covered with masses of marble detached by frost, or loose angular fragments blasted by the men and thrown down the mountain side for the purpose of uncovering the best beds. These steep inclined planes, termed *ravaneti*, afford the means of rolling down the blocks of marble from an immense height, no mechanical contrivances being employed; they reach the bottom carrying along with them much *débris*. Being pure white, and not weatherworn and grey, like the rest of the mountain, these *ravaneti*, or rubbish slopes, present a dazzling appearance in the sun, and may be readily distinguished for seven or eight miles, as a characteristic feature in the landscape.

Crestola and Cavetta quarries produce the most esteemed marbles, having when polished a delicate and almost waxy hue, due to the presence of a small quantity of carbonate of iron. The crystalline acets are very large, and are easily seen even in a finished statue. Crestola marble is highly prized for its tenacity; it can be worked into the finest forms in sculpture, so that the sharpest edges can be preserved; this is not so much the case with Polvaccio and Betogli marble.

Poggio Silvestro quarry, precisely on the opposite side of the valley, produces marble of a superior quality.

Betogli marble must not be left at the quarry a long time exposed to the air before it is used, as under such circumstances it deteriorates, losing considerably in specific gravity; so that it becomes unfit for many purposes. If a thin slab be left for some time supported against a wall it sometimes bends, owing to the slight degree of elasticity that it possesses. Repetti mentions that the inferior degree of density in structure renders it peculiarly liable to the reception of colour, and Sig. Monti has assured me that, when exposed to the air of London, the soot penetrates to the depth of 1 or 1½ inches in a very short time, so that it disintegrates at the surface. Nevertheless, as Betogli marble is easy to work, it is liked by sculptors, and for internal decoration and statuary, not intended to be

placed out of doors, it answers very well; indeed in the Florence Exhibition last year there was a most delicate bouquet of flowers with leaves sculptured in Betogli marble by Sig. Bonnanni.

Mossa quarry furnishes an exquisite opaque marble, the nearest approach to ivory-white, and valuable for draped statues.

Polvaccio has a more than usually eventful history. For two thousand years the produce of this quarry has been brought under the chisel of the most celebrated sculptors. The statuary marble found here is fine-grained, and of an agreeable white tint; it can be chiselled with the greatest facility in every direction, but it is impossible to assure oneself against finding minute cubic crystals of iron pyrites here and there, and hard silicious grains called *smeriglio*, much to the annoyance of sculptors. Polvaccio and Betogli marbles are translucent when first quarried, but lose this property when exposed a long time, whereas Crestola marble retains its translucency. One of the greatest advantages of the quarry is the ease with which large masses of statuary marble can be obtained. Canova's colossal statue of Napoleon, in the Duke of Wellington's house, was sculptured from a block of Polvaccio marble measuring nearly 600 cubic palms, without any flaw. I saw at the quarry a monster rectangular block, measuring 1,155 cubic palms, or 18 cubic mètres—588 cubic feet, for which Messrs. Fabbricotti wish to obtain on the spot £1 per cubic palm, or upwards of £1,000. It will most probably be purchased by the Russian government for the equestrian statue of the Emperor Nicholas.

The more opaque marbles, of which there is abundance in this valley, are called common white (*marmi ordinari*), in contradistinction to the statuary kinds, and from their resistance to atmospheric action are employed in architecture.

At the adjoining quarries of Grotta Columbara and Fossa Cava, very long pieces of common white marble (*ordinario*) can be excavated; hence was obtained the marble for some of the lofty columns of the church of S. Francesco di Paola at Naples.

Canal Bianco produces a slightly bluish *ordinario*, of the very best kind for architectural purposes.

Ravaccione marble is perfectly homogeneous, and as strong as any other for resisting at the edges; it is much used for ordinary sculpture.

The marble beds are frequently traversed by ramifying veins of magnetic oxide of iron, of varying size; these appear to have exerted during their formation a powerful influence on the limestones. When only from a tenth to half an inch in width, the magnetite presents itself in the form of isolated octohedral crystals. In the regular and larger veins it is a lamellar ore; the marble in juxtaposition assumes a warm waxy lustre, of great beauty, and is susceptible of the highest polish. The magnetic oxide either communicates a lovely violet tinge to the marble, or, losing a part of its oxygen, passes to the state of protoxide, and combines with the carbonic acid liberated from the limestone, becoming spathose ore, or carbonate of iron. These violet marbles are known in commerce as *Paonazzo*.

Boccanaglia quarry furnishes *paonazzo* with deep violet streaks, but the handsomest is that from Sponda, a breccia with rounded translucent white patches, cemented by violet markings.

Returning as far as the first houses of Carrara, and then ascending the rivulet called the Canal di Bedizzano, after proceeding a mile and a half we turn to the left, up the course of a branch valley, lined on either side with important quarries. The ridge of the mountains to the left is already familiar to us, being that extending from Betogli to Polvaccio.

The marble from Vara quarry has a beautiful white colour, with slate-coloured veins. It is much esteemed for ornamental purposes, and may be quarried in immense blocks.

Finocchioso quarry is worked for *bianco chiaro* and *paonazzo*, with broad and extremely handsome violet markings. The latter beds run through the mountains in a northerly direction to Sponda.

Fantiscritti, at which we now arrive, at the head of the valley, furnishes blocks of any required dimensions. Some of the columns for the church of S. Francesco di Paola were procured here. The name of the quarry is derived from an ancient Roman basso-relievo, still well worthy of observation, in spite of barbarous travellers, who, to satisfy a morbid desire for acquisition, have much injured it by chipping off pieces. Not far off the names of Michaelangelo and other eminent sculptors are cut in the face of the rock. Such is the quantity of waste materials which has been extracted from this quarry that the *ravaneto* of rubbish thrown out has almost filled up the valley for a quarter of a mile.

Some years ago a prodigious block of ordinary marble was blasted at this place from a very elevated spot in the mountain. Descending along the *ravaneto*, and crushing the smaller stones to powder, thereby raising a cloud of dust like a cannon when fired, it took fabulous leaps like a titanic football, rushing up the opposite slope with the impetus it had acquired, while a torrent of stones displaced by it danced about and tumbled over and over with rattling noise, dashing with violence against the ledges of rock. Meanwhile the huge mass, once more swaying

round, again continued its headlong course, until, having proceeded nearly half a mile, it broke in two, but not before killing some poor quarrymen, who could not tell where to run. Those who have not been eye-witnesses of such scenes can scarcely picture to themselves their grandeur.

Once more retracing our steps to ascend the Canal di Bedizzano, we first find on the left the quarry of Belgia, the marble from which can be excavated in immense blocks, The *road* at this point becomes more and more impracticable until we arrive at Colonnata, where it ceases. At this village there are numerous quarries, such as Fossa Cava, Gioia, and Nartana, but want of road communication is a serious drawback to the prosperity of this place.

Hitherto, for the mere sake of sequence, it has been thought advisable to speak only of the white marbles. I will now proceed to the coloured varieties, which are found in the same localities as the former.

When the process of purification of the marble has not been completed, and when it does not contain elements capable of crystallization, but much organic matter, it assumes a slate colour, streaked more or less with black or dark grey veins. This is known as *bardiglio*. At Carrara, where the markings are rare, this stone is not sought after. Perhaps the best is that of Gioia. A few quarries produce white and black and veined black marble. Other varieties, though rare, are black and gold, similar to inferior *portoro* marble, and pure black, found at Gragnano and Colonnata. Still describing the rare varieties, there is dark green, veined with yellow; peach-coloured breccia, consisting of minute elements, tinted with microscopic madder-coloured spots. The red breccia from Monte d'Arme is among the finest in Europe. The *mischio* from La Rochetta, a mile above Carrara, and the chrome yellow breccia from Peschina were chosen for decorating Napoleon's tomb at Paris. Cocchi considers these breccias to be of the same age as the Indian yellow marbles of the Montagnuola senese, of which more hereafter. They are exquisitely beautiful, but, after long and careful search, I was reluctantly brought to the conclusion that it would be impossible to calculate on procuring them in large masses, for the rock, more a limestone than a marble, changes in character at the distance of every few feet, in addition to its being often of a very cellular structure.

To attempt any description of the first opening of the white marble quarries of Carrara would be vain; they evidently sprung into existence in very remote times. Etruscan antiquities are frequently sculptured in marble, though they are so much worn that it is difficult to ascertain by its structure if the material employed came from this district.

In the later days of Etruria flourished the Etruscan town of Luna, since called Luni, within eight miles of Carrara, described as having a good harbour of refuge at all seasons of the year. "Primum Etruriæ oppidum Luna, portu nobile." (Pliny, Lib. iii. c. 9.)

What may have been the importance of Luni as a commercial town it is difficult to say, but the following passage from a poet of the Lower Empire informs us that it was surrounded by snowy white marble walls, rivaling the lily in radiant purity:—

> Advehimur celeri candentia mœnia lapsu
> Nominis est auctor sole corusca soror.
> Indiginis superat ridentia lilia saxis
> Et lœvi radiat picta nitore silex
> Dives marmoribus tellus, quæ luce coloris
> Provocat intactas luxuriosa nives."
>
> (Rutilius Numanzianus; *Itiner.* Lib. II. in fine.)

Ciriacus Anconitanus visited Luna, already in ruins, in 1442, and also speaks of the vast proportions of the marble blocks of which the walls were built; some of these he found by measurement to be 8 feet by 4. "Ad xii Kal Octobris venimus Lunam vetustissimam Ligusticæ urbem, ubi primum diserta longinqua vetustate mœnia vidimus . . . . . et cum diligentius ab occidua tanta civitatis parte confracta ingentiaque olim mœnia conspexissem, marmoreis, magnisque lapidibus fuisse comperimus, nam viii p. long, latitudinis vero iv. nonnullas mensuravimus lapides."—(*Nova fragmenta*, p. 16.)

The destruction of the town of Luna must be ascribed, I think, in great measure to the filling up of the port with alluvium from the Arno and the Magra; indeed, after heavy rains have fallen above Florence, it is easy to observe a yellowish colour in the sea, on the coast opposite Luni, derived from matter held in suspension. Mr. Walton, of Carrara, informed me that the sea retires as much as a metre a year, as measured by his pier. Luni is now at least 1½ miles from the sea, from which it is separated by meadow land. The name is still recognisable in the word *Lunigiana*, applied to the neighbouring part of the province. I examined many fragments of marble which I picked up in the fields on the site of Luna, and, from careful observation of the structure, fully concur in the opinion of such archæologists as consider that it came from quarries near Carrara. Some years ago there still remained large blocks of marble, believed to have formed part of the sea-wall of Luna, from the circumstance of a metal ring being discovered in one of them, such as were used to attach galleys to the piers. The architects of the dark ages, in order to embellish the churches of the neighbouring town of Sarzana, profited by the declining state of Luni to rob it of marble columns and squared blocks, and these may be now examined by any one, and easily recognised from their incongruity with the style of architecture of the

rest of the building. Little, indeed, has been allowed to remain at Luni. I could only see about a dozen rectangular marble blocks, which I believe to be from Carrara, together with the ruins of the amphitheatre and the foundations of a few buildings.

The Romans, having brought over a large quantity of Grecian statuary, especially during the luxurious days of the Empire, directed their attention to their own beautiful white marbles of Carrara. A passage from the fifth book of Strabo's Geography would show that there must have been a considerable degree of skill in working the marble among the inhabitants of Luna, for he states that in his time the Apuan Ligurians were employed in building the most splendid edifices at Rome, where, even in the environs, villas sprung up no way inferior in splendour to the palaces of Persia. —(Repetti, *Sull' Alpe Apuane*, p. 92.)

In 1810, an important inscription was found buried in the valley of Colonnata, above Carrara, sculptured on a piece of white marble similar to that quarried on the very spot, and bearing the names of Decius Hslerius Agrippa and Caius Sulpicius Galba, consuls in the 8th year of Tiberius, *i.e.*, A.D. 22, being the reign in which Strabo wrote, and showing that Carrara marble was then worked.—(S. Quintino, *Atti della R. Accademia di Torino*, 1823, p. 267.) I noticed two monumental inscriptions about a mile from Miseglia, the property of a gentleman, who had discovered them close to his house; another, of the time of Septimus Severus, was found in the neighbourhood many years ago: numerous others have, doubtless, been destroyed by the villagers, to whom fragments of statuary marble are but as road-metal. Polvaccio quarry, four miles north-east of Carrara, is acknowledged to date from Roman times, and to be the spot whence the marble for the Pantheon was obtained. Though originally erected by Agrippa, B.C. 26, that superb building is still in a good state of preservation. But the most interesting relic at Carrara is the basso-relievo, attributed to Roman times, which I visited at the quarry of Fantiscritti, representing Jupiter, Hercules, and Bacchus standing together. It is sculptured on the vertical face of the living rock, in a very inaccessible part of the quarry, several hundred feet above the valley. It has excited great attention from antiquaries, but the age cannot well be determined. I append an engraving of this inscription, kindly copied for me by Prof. Pelliccia, at Carrara.

Pliny says that Mamurra, a Roman knight, and prefect of Cæsar's smiths in Gaul, incrusted his villa, on the Mons Cœlium at Rome, with Lunar marble, all the columns being of the same stone, and that he was the first Roman who thus employed marble for house decoration. (Pliny; Lib. i., cap. 36, sect. 7.)

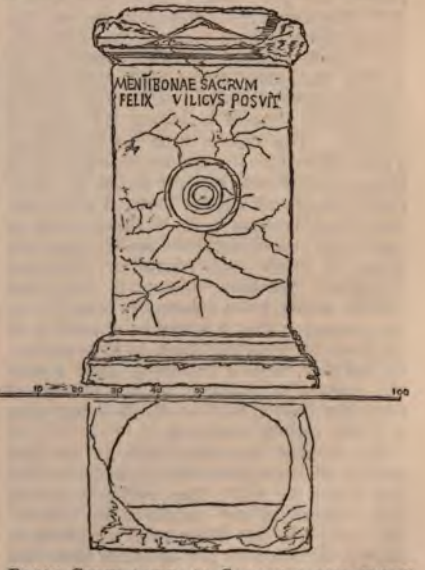
On the very reliable authority of Repetti, who was a native of Carrara, the following

ROMAN BASSO-RELIEVO, SCULPTURED ON THE ROCK AT FANTISCRITTI QUARRY.

objects of ancient Rome have been verified to be of Lunar or Carrara marble:—

The doorway of the Pantheon.
The theatre of Gubbio.
The palace and arch in Via Domiziana.
The baths of Caracalla.
The bust of Cicero in the Borgia museum.
Apollo Belvedere, excavated at Nero's Villa, mentioned by Pliny. (Repetti; *Sopra l'Alpe Apuane*, p. 177.)

The first mention of the word Carrara, as far as I can learn, is of the year A.D. 963. Repetti, with what truth it is difficult to say



ROMAN CIPPUS FOUND AT COLONNATA, NOW IN THE ACADEMY OF FINE ARTS AT CARRARA.

derives the etymology of the word from *Curro*, or waggon, in which marble is conveyed. The root is also found in the word *Carrione*, the name of the river passing through Carrara, while the arms of the town are still a cart wheel. Other authors consider it more probably derived from the gallic word *quarriera* or *carrière*, quarry. Frederick Barbarossa, an Emperor whose name I have in three instances found associated with mines and quarries, issued Imperial diplomas in 1183 and 1185, giving the Bishop of Luni, among other things "Curtem Carrariæ cum Alpibus lapicidinis etiam marmorium cum montibus, &c."—(Quoted by Repetti, *Op. Cit.*, p. 35.)

"Aronte.....
Che nei monti di Luna dove ronca
Lo Carrarese che di sotto alberga,
Ebbe tra bianchi marmi la spelonca
Per sua dimora, onde a guardar le stelle
E'l mar non gli era la veduta tronca."
— Dante; *Inferno*, Canto xx. v. 49-54.

In the dark ages marble was extensively employed in Tuscany for building churches and palaces. Agostino del Riccio mentions that Carrara marble was brought for the cathedral of Florence in 1366 and 1389, though white marble had been previously obtained from Rosia in the Senese, in 1364, of which more hereafter. But particularly at the time of the first sovereigns of the Medicis dynasty were the quarries worked to any extent. The Grand Duke Cosmo I. had a great passion for the fine arts, and was a liberal friend to architects and sculptors. Buonarotti, better known as Michaelangelo, was commissioned to undertake many great works, and not being able to trust to others to select the best stone, frequently went to Carrara to visit the quarries, stopping there for several months at a time. He directed his attention to that of Polvaccio, renowned for the size of the blocks, and which had furnished him the material for his celebrated David, in the Piazza della Signoria at Florence.

Vasari says that Simon of Fiesoli had already roughed out the block to make a colossal statue, but having modelled it so badly, the work was abandoned. Michaelangelo had long looked at it with envy, and some years afterwards, applied to have it given to him. Soderini, the Mayor of Florence, who considered the block as useless, more especially as it was worked out between the legs, and judged that anything would be preferable to leaving it in the state in which it then was, handed it over to him. Michaelangelo, then only twenty-nine years of age, modelled the figure of David holding a stone in his hand for the front of the Palazzo Vecchio; the idea being that as David had defended his people, and ruled them with equity, so whoever held sway in Florence should defend it courageously and govern with justice. The statue was executed in the cathedral, and taken to its destination suspended by ropes and enclosed in a wooden frame. Pier Soderini, as is well known, considered it necessary to pass some criticism, and while expressing his delight, said that he thought the nose was too large. Michaelangelo perceiving that the poor Gonfaloniere was utterly ignorant of the merits of his production, pretended to take the hint, and having dexterously picked up some marble dust, jumped up on the scaffolding erected round the statue, and, arrived at the height of the head, he seized a chisel in the sight of Soderini; he feigned for some time to work away at the nose, letting the dust fall by degrees. At length, looking down towards Soderini, who was intently engaged in watching the operation, he said, "What do you think of it now?" "That pleases me more," cried Soderini, whose *amour-propre* was satisfied; "you have imparted life to it." Poor Soderini's presumptuous criticism has immortalized him. (Vasari; *Vite de' più eccellenti pittori, scultori ed architetti, Bologna*, tom. i. pt. 1, p. 142.) Michaelangelo received 400 crowns for his work, which was erected in 1504, and has ever since remained exposed to the open air on the Piazza della Signoria. Unfortunately, the left arm was much injured in a riot in 1527, but still this statue procures the admiration of all who have seen it.

Michaelangelo subsequently visited this quarry on frequent occasions, and chose, on the spot, the blocks for those speaking statues of Day and Night, Dawn and Twilight, on the tombs of Juliano and Lorenzo de' Medici, in the church of San Lorenzo (Vasari; *Vite dei più excellenti pittori, scultori, ecc;* Siena, 1793, tom. 10, p. 61), which must have left on the mind of everyone who has examined them the belief that they only want life to be perfect. Some of my readers may not be familiar with Michaelangelo's vigorous lines on this statue of Night, in reply to a sonnet by Strozzi:—

"Grato m'è il sonno e più l'esser di sasso,
Mentre che il danno e la vergogna dura;
Non veder non sentir mi è gran ventura:
Però non mi destar; deh! parla basso."

Michaelangelo, visiting Carrara in 1515, is said by Vasari to have proposed to convert the summit of the hill north-east of the town at a distance of five miles from the sea, into a gigantic statue, which might serve as a landmark for vessels sailing by. About the time of which I am speaking, the Neptune of the fountain of Ammanato, and the group of Hercules destroying Caccus—also in the Piazza della Signoria at Florence—were chiselled from blocks taken from the Polvaccio quarry. Vasari speaks very highly of the quality of the marble from Polvaccio, saying that it is easy to work, and that the artist is less liable to find imperfections in it than in many others. (Vasari, tom. 1. p. 15. . . Edition.)

The MSS. Public Archives of Carrara,

which I examined, give the number of quarries in the commune granted to various persons during the last eighty years; but, of course, all are not worked.

1779	430	Without counting those entirely abandoned.
1815	434	
1830	467	
1845	559	
1860	655	

2. Massa.

It was only in 1836 that Counts Paolo and Michele Guerra, together with two other citizens of Massa, Sig. Compagni and Giorgini, determined to investigate the nature of the marbles of Massa, bringing over a master quarryman from Carrara to commence their operations; but up to the year 1850 little progress could be made, through the incessant jealousy of the Carrarese, who sought to crush this new enterprise in order to retain their monopoly. I have even been informed that certain merchants sold inferior Carrara marble as the produce of Massa, in order to depreciate the value of the latter. About 10 years ago the fact of Massa marble being of excellent quality seems to have been so fully established that henceforth the Carrara opposition was of no avail. The number of quarries opened already amounts to 80 or 90, and they are constantly on the increase, for not a tenth part of the mountain has been examined with due attention. To the present moment however, most of the proprietors sell their marble as *Carrara* stone, for such is the value of a good name and the force of public prejudice, that while there would be considerable difficulty in selling blocks to please connoisseurs if they knew it were Massa marble, in their ignorance of the fact they are perfectly satisfied with the material.

The first marble quarries in ascending the Frigido are those of the Canal del Fico, a lateral valley descending from Monte Rocchetta on the watershed line between Massa and Carrara. A group of a dozen quarries have been opened at the higher part of the valley, by Guerra, Brothers, Michele Guerra, Hähner, and the *Compagnia marmorea italiana*. The section of the strata in descending order is as follows:—

Somewhat schistose rock, limestone and impure marble.
Statuary slightly veined.
Veined and spotted white architectural marble (*moschetato*).
White marble (*bianco chiaro*).
ardiglio, 60 feet thick.
Greyish limestone (*grezzone*), 1,000 feet, at the base of the marble series.
Palæozoic schists with quartz, the same rock in which are found the copper veins of the Frigido.

Saineto, Guglielmo, Ciufi, and Cava Grande furnish more or less yellowish statuary of second quality, but hitherto not in large blocks. A peculiarity of the *Bardiglio* from Saineto is, that when first quarried it seems to be of an uniform dark slate-blue colour, but by exposure to the air and the sun the ground fades, so that the veins come out in stronger relief.

Passing the ridge of the mountain spur towards the north, we first enter the quarry of Pianella, in the parallel Canale di Casetta, and then the quarries of Piastrone and Piastriccione. Perhaps no spot could be more favourable than this valley for observing the stratification of the beds below the marble; in the lower part they are horizontal, while in ascending the valley they curve downwards, until, at Piastrone, the property of Sig. Michele Guerra, they are nearly vertical. I should consider the vertical position of the white marble beds at Piastrone a circumstance offering great advantage in making columns, especially as they might be obtained 30 or 40 feet long, for they would lay in the same position in the building as in the quarry, whereby the pressure would be retained in the direction in which it had always been exerted. Piastrone extends to the crest of the hill, overlooking the Carrara quarries; indeed, Gioia adjoins it on the opposite slope, and is the continuation of the very same beds. At Piastrone is quarried a very pretty white architectural marble, dotted over with small slate-grey spots, of the size of a fly, interspersed with veins, whence its name *bianco moschetato*. In England it is preferred when the fine veins predominate; in Holland when much spotted and veined; and in Belgium when there is only a small quantity of spotted markings.

Following the river to the place called Pollo (source) del Frigido, because the Frigido there receives an abundant perennial supply of water from a subterranean chasm in the rock, although by no means at the head of the water-course, we pass the hamlet of Forno, situated among Palæozoic schists, and arrive at Biforco, the junction of the Canali di Cerignano and del Fondone, where the white marble strata again appear. From this point the principal proprietor is Sig. Wagner. The Canal di Cerignano yields ordinary marble and white, easily distinguished from all Carrara marbles by the minuteness of the grain; being opaque white, it is very good for architecture and statuary. The statuary marble from Eugenia quarry, on the left slope, is excellent to work, having no quartz grains, and being of fine but distinctly crystalline structure. Sig. Wagner is now pushing forward a track along the Fondone, for the purpose of transporting the magnificent marble lately discovered at that place. Rava, for instance, on the left bank, yields the best

ordinario; and higher up, FONDONE, a perfectly new quarry, contains a vein of statuary marble with so delicate a rosy tinge as scarcely to be perceptible by ordinary observers. A little below Biforco, on the northern side of the valley, is a quarry, AL FICALE, whence a superb new red breccia with wax-white ground is obtained, of which several specimens may be seen in the International Exhibition.

A few quarries are situated high up the Canale di Antona. The statuary marble from CAMPO FRANCESCO, belonging to Sig. Landriani, is of first quality, and may be sawn into extremely fine slabs, as for inlaying, &c.; it does not chip or form scales by the blow of the hammer, as do many marbles, and is consequently admirably adapted for flowers and very fine monuments. Prof. Isola, of Massa, exhibited last year a highly ornamented looking-glass frame and stand made of marble from this place. The ordinary marble of Campo Francesco, is extremely strong, and has a blueish tinge.

Close to the summit of Monte Carchio, on the south side, is the quarry called CARCHIO. The *ordinario* at this place is whiter than usual, and is peculiarly sonorous, so that on giving detached blocks in the quarry a heavy blow with a hammer, they ring with the clear musical note of iron striking on an anvil. As might have been anticipated, it is extremely strong, and the edges may be made very sharp; nevertheless, some say it is difficult to work. *Bardiglio*, with veins and patches of whitish grey, likewise occurs here, but it is of inferior quality. At the base of this quarry is that of CARCHIETTO. The grain of the statuary marble is fine and the colour good, but nothing could hitherto be done for want of a road to Montignoso, the only way by which it could be conveyed. These are the lower beds resting on Palæozoic micaceous schists. Without further experiments it cannot be judged whether the marble could be obtained in sufficient quantities free from impurities.

The two latter quarries are in the Commune of Montignoso, and adjoin those on the Tuscan side, near Monte Cappella, on the rivulet Serra.

Lastly, we may specify a few of the new quarries found on the Canal di Resceto, a torrent rising in Monte Tambura, with its lateral branches. A mile above its junction with the Frigido, on the north side, high up the mountain and overlooking Casania, is NIDO DEL CORVO. This quarry produces statuary and also white marble (*bianco chiaro*), which cannot be recommended on account of the numerous veins of calcareous spar running through the rock; this, being of unequal hardness, causes it to split while being sawn or worked. On the other hand, at the base of the white marble is found an exquisite sanguineous breccia of the most varying colours. The basis is white, from crystalline statuary to compact marble, and even to calcareous spar. Interspersed with this are rose-red streaks, tinged at the edges with delicate warm yellow and other colours. There is but little cementing matter, and that little is perfectly free from schist, so that no one one could mistake it for the *mischio di Seravezza*, to be elsewhere described. From the difficulty of obtaining this lovely stone in large quantities, or guaranteeing what it may be previous to sawing a block, it sells as high as statuary marble; the more so as it often contains flaws: but with all these difficulties I conceive it might be employed to great advantage in inlaying. Count Guerra has sent two table-tops of this stone to the International Exhibition, one of which most persons will agree to be unsurpassed in beauty by any marble in the building. Although ½ an inch thick, such is its translucency that, by placing a candle underneath, the rose-red streaks come out quite distinctly.

A little above Casania is a mill at the junction of the Canali di Resceto and dell'Olmo. In the latter valley there is not the trace of a road, but the quality of the statuary marble is excellent. At PALAZZUOLO quarry, for instance, are beds of very strong, fine-grained white (*bianco chiaro*), fit for ornaments and out-door sculpture. The works are only experimental.

TANETO quarry is at the head of the Vallata di Taneto, a branch of the Canal dell' Olmo. The geological section is here very similar to that on Monte Corchia, above Levigliani, namely:—

Fine grained white *ordinario.*
Bardiglio.
Variegated breccia.
Mischio, like that of Seravezza.
Compact liver-coloured limestone, *persechino.*
Grey limestone.
Grezzone.
Palæozoic schists.

From elevated spots the dip of the beds of marble may be distinguished all the way from this place to Piastrone, being harder than the rocks below, so that they form a kind of vertical wall, and at their base the schists form a gentler slope.

Count Guerra has pushed his researches to the summit of the mountains, where he has commenced the quarry of VESTITO at a point within a few minutes' walk of the ridge connecting Monte Altissimo with the Tambura. The *mischio* of Vestito would most probably answer very well for inlaying columns, &c., and is very similar to that of Rondone, at Seravezza.

The quantity of Massa marble exported from the beach is rapidly on the increase, and was already a source of considerable revenue

to the late Government of Modena. The following table was given to me by Count P. Guerra :—

Years.	Tons exported.	Export duty levied.	Average per ann.
		£ s	£
1836–1845	1,189	169 16	16
1846–1855	15,048	1,370 12	137
1856–1859	19,992	1,196 10	300

The present Government has abolished the tax, in place of which a toll of 2 francs (1s. 8d). is levied by the town on every two-ox waggon load passing through the gates.

There are 11 sawing mills with 55 sawing frames, at Massa, and 9 circular machines for polishing slabs and flagstones. In 1847 there were only 2 mills, with two sawing frames each, and 2 polishing machines.

3. Seravezza.

As at Carrara, by far the most important and extensive beds at Seravezza are lower liassic white marble, as between Seravezza and Ruosina; the best and most abundant is that of the Falcovaja quarries, on Monte Altissimo, eight miles north of Seravezza. Here the limestone, to the very base, has been transformed into white marble of great beauty. The stratification is completely destroyed; it is difficult to find it free from veins, but the yellowish tinge of the finer parts causes it to be much prized.

Nothing can be grander and more imposing than the sight of Monte Altissimo, as it suddenly bursts into view in ascending the little rivulet Serra; one can scarcely believe that these precipitous crags are composed of sedimentary rocks. The mountains here form an amphitheatre, with rugged bold summits rising to the height of 5,440 feet; so steep is the ascent of its almost perpendicular flanks, that it can only be approached on one side. The whole summit of Monte Altissimo seems to have borne the brunt of more than its share of thunder storms and tempests; it is rugged and denticulated in the most surprising manner; the crest in many places is as narrow as the ridge of a roof. At a distance I should at first have pronounced it to be the interior of a volcanic crater.

Towards the east of Monte Altissimo the summits of the mountains are chiefly composed of white marbles; such as the Pania della Croce and the nearer Alpe di Levigliani, a branch of Monte Corchia. It is an inexhaustible and little explored field of wealth. All these lofty mountains are in Tuscany; Monte Carchio, two miles west of the Altissimo, forms the boundary beween it and the province of Massa-Carrara; and no sooner do we reach the crest than the *eye* soars, as in a panorama, over the very extensive series of quarries that we have been describing, extending with little interruption above Massa to Carrara.

Up to the 15th century it would appear that the Tuscans invariably obtained their statuary marble from Carrara, which then belonged to the Marquis Alberigo Malaspina, at whose death, in 1519, Carrara passed into the hands of the Cibo family. It is said that Leo X., who was a Medicis himself, having heard that in the Florentine dominions there existed, on Monte Altissimo, one of the loftiest peaks, marbles of the same quality and beauty as those of Carrara, ordered a letter to be written to that effect to Michaelangelo, who was then at Carrara, superintending the excavation of the stone for the tombs of Juliano and Lorenzo. The sculptor, to whom the announcement was by no means new, whether from fear of offending the Marquis Alberigo, the lord of Carrara, to whom the quarries necessarily brought in a very considerable revenue, or from dislike to go so far, thereby incurring great loss of time, did not seem to desire to pay any attention to the command. He was, however, compelled to comply, in spite of the manifold objections he raised on the score of the expense, which turned out perfectly correct. Passing into the *enclave* of Tuscany, which took in the valleys of the Versiglia, not long before ceded to that government, he ascended the Altissimo above Seravezza, and discovered an eligible spot for a quarry on the Costa de'Cani, on Monte Capella, in 1518. He then speedily completed five columns, one of which was taken to the church of San Lorenzo, in Florence, in 1521, (Giov. Cambi; *Cronica fiorentina*) the rest still lay on the shore near Pietrasanta when, thirty years subsequently, Vasari wrote his life of Michaelangelo.* Thus did the Marquis Alberigo, spoiled of his monopoly, become one of the bitterest enemies of Michaelangelo. (Vasari; *Vite dei più eccell. pit. ecc.*, tom. 10, p. 98.)

Michaelangelo had a very laborious task before him. He is acknowledged to have been an universal genius, emphatically styled "the man with four souls;" but it may not be generally known that on this occasion he had become a road engineer. The first necessity for him was to make communication through several miles of the most rocky country, along the narrow valley of the Serra. This object being to a certain degree attained, he was able to ship off his blocks for conveyance by sea, and up the Arno to Florence. He appears to have been extremely averse to the task, and writes to his sovereign in very quaint and plaintive style, "The mountain in which the quarry has to be made is very rugged; the peasants excessively ignorant of the duties required of them; great patience and a long

* These columns were never put up on the façade of S. Lorenzo.

time will be requisite before the mountains will be made accessible (*addomesticati*), and the men trained (*ammaestrati*)." (Quoted in *Studj di Statistica sull' Italia, Torino*, 1859.)

To show what progress these quarries of statuary and white marble, and those of *mischio* and *bardiglio* mentioned above, must have made after the lapse of a few years, I will quote a passage written by Cosmo I. to Matteo Inghirami, in 1565:—"For our part, and the works in our State, we will not, in any way whatever, permit the marbles of Carrara to be employed."—(Repetti, *Diz.*, tom. v., p. 264.) We soon find other sculptors and architects besides Michaelangelo and Vasari proceeding by royal mandate to the valleys of the Versiglia. Amongst others, Giovanni Bologna went there two years later, in 1567-8. The conveyance of the blocks of marble to the coast in those days would seem to have been an event for the town, if we may judge from a letter of Giovanni Bologna to Prince Francis of Tuscany, in which he describes at some length one of his trips from Seravezza to the shore, amid the ringing of bells, the clang of all kinds of wind instruments, and the noise of men and women shouting *palle! palle!* From this time the interest of the Grand Duke Cosmo I. and his son and successor Francis I., in the mineral wealth of the newly-explored mountains increased to such a degree that we find the Medicis sovereigns making Seravezza their summer retreat, locating themselves in a palace in that town. Here they delighted to while away their time amid the glorious scenery of the marble mountains, and spent many an hour in trout-fishing in the streams.

But this sudden prosperity was not to last. The favour of princes is proverbially fickle. Mining cannot be permanently successful in the hands of any but practical people, and all the restrictions put upon it by the Medicis, by which they constituted themselves sole proprietors of the minerals and marbles of the state, was the surest way of destroying this branch of industry. That splendid family, steeped in crime, had probably thought to propitiate high Heaven by erecting marble altars, and to screen themselves under marble vaults; or, to quote the remarkable and truthful words of Roscoe in reference to the statue of Lorenzo de' Medicis, of which I have spoken above; "As the Egyptians embalmed a putrid corpse with the most precious odours, so artists and poets too often consecrate their divine talent to the most worthless men." But these princes were soon extinguished in ignominy, and the quarries fell into oblivion. Things remained in this state up to the latter half of the eighteenth century, when Leopold I. released the marbles from government monopoly.

In 1827 there were only eleven small quarries in the territory of Seravezza. In 1820, Signor Borrini began to re-open quarries on the Altissimo, which had been neglected during two centuries, and discovered that of Polla. In 1840, Borrini, with some other gentlemen, started a company for working the marbles of Monte Altissimo, under the title "Sancholle and Co.," consisting of 1,800 shares, each of 1,000 Tuscan *lire*. Of the *Ordinario*, from the Polla quarry, on Monte Altissimo, are those employed from 1835 till very recently in making that series of statues of celebrated Tuscans under the portico of the Palazzo degli Uffizi, at Florence, which were the result of lotteries patronised by the government. The statue of "Florence Victorious," in the *Salone ducale*, is equally of Altissimo marble.

At Falcovaja quarry the *bianco ordinario* rests immediately on the *grezzone*, a yellowish grey limestone, with white veins and markings. The *ordinario* at this place is white, hard, sub-translucent, and homogeneous. It has not the blueish tinge of that from Ravaccione, Fantiscritti, and other quarries at Carrara. The extent to which this quarry has been worked may be judged from the immense size of the chasms cut in the rock at several points. Accompanying the *ordinario* are several beds of the best fine-grained statuary marble of two kinds, white, and delicate flesh-coloured yellow (*carnicino*), rather similar to that obtained from Poggio Silvestro than of the alabaster-like appearance of certain marbles from the vicinity of Betogli. The inferior degree of translucency is probably to be ascribed to the presence of a larger quantity of carbonate of iron. Being often of the peculiar opaque white of biscuit porcelain, I was told by Professor Santini, of Pietrasanta, that it casts more definite and sharp shadows than many of the Cararra marbles, which frequently present reflected shadows. It often suffices to examine two statues together to perceive the great difference there is between them. The best statuary from the Falcovaja is pronounced to be superior to Carrara marble, on account of its homogeneous structure and absolute freedom from grey veins. The grain is much finer and less lamellar than that of Carrara marble, but the fracture is far more concave; the action of the atmosphere is said rather to improve and render it harder.

Looking down from Falcovaja, Polla quarry is seen just below, at the opposite side of the ravine. Vincarella is higher up the hill, and just between them. Vincarella also contains beds of *Bardiglio*, and veined white is found at the quarry called Sotto la Polla.

All these quarries are difficult of access, except from the side of Monte Corchia. If the proposed road from Ruosina to Castelnuovo di Garfagnana be ever made, it would come within a quarter of a mile at the pass

Foce dell Cipollajo, whence it would be very easy to make a branch road to the quarries. At present there is *not even a footpath*. The blocks of marble are moved with rollers and pulleys to the edge of the precipice or *ravaneto*, whence they roll down on the fragmentary rubbish into the valley, much to the detriment of the material, besides the great expense in the loss of blocks which get off the proper track. No less than 21,000 cubic palms of statuary marble from Falcovaja, and 100,000 cubic palms of white marble from Vincarella and Polla quarries, have of late years been furnished by the Monte Altissimo Company, for the construction of the cathedral of St. Izaak, at St. Petersburg. The two former kinds have also been employed in the Tribune of Galileo, at Florence, an architectural gem by Commendatore Martelli.

The GIARDINO quarries are situated in the vertical face of the Altissimo, half a mile to the east of Falcovaja, at the source of the torrent which flows into the Vezza, at Ruosina. Having had the advantage of going over the ground with the enterprising proprietor, M. Sancholle-Henraux, of Paris, I am induced to recount some of the incidents connected with these excavations, and how they originated. M. Sancholle had long had his eye fixed upon this spot, from the fact that he had frequently seen detached pieces of fine marble lying in the winter torrent; but the question was how to get at the place whence they were broken. He followed the water-course from Ruosina to its source, and wandered over the rocks, pursuing a track fit only for goats, sometimes spending whole nights in the mountains from the difficulty of getting backwards and forwards. In 1847 there was a great dearth, and some quarrymen were induced to venture up in the same direction in search of marble. Having found a detached block in the upper part of the valley, after untiring exertions, warranted only by the misery to which they were reduced, they brought it to Seravezza, where its superior quality ensured its sale. M. Sancholle, meanwhile, did not desist from his labours, but before him was a steep precipice of 1,000 feet, corresponding to the dip of the strata, and extending in the direction of the cleavage of the rocks. This cliff he ascertained to be the first bed of white marble, for up to its base are Palæozoic schists and *grezzone*, with half-purified marble.

The next point was to send men to the summit of the precipice, and let them down with ropes fastened round their bodies, after the manner of the Shetland eider hunters, to chip of fragments here and there from the rocks. Great was his delight in finding that though much weather-worn it was really statuary marble of superior quality, and very analogous to that so highly prized from the Falcovaja quarry. M. Sancholle wisely set to work at once at his own expence to make a waggon road to convey the marble as far as Ruosina, two miles distant, to which place communication has long existed. The difficulties of this undertaking were vast, for the torrent being at right angles to the mountain chain, has a very rapid descent, and passes between rocky banks. At one place especially, called the Paradiso dei cani, a frowning precipice, upwards of a hundred feet high, yawns over the stream. By the expenditure of time, skill, and a large sum of money, the road was completed in 1859 up to the marble wall. The quarries are still only in their infancy, for the most essential part remains to be accomplished—namely, the approach to the wall itself, and the formation of inclined planes for the descent of the statuary marble. At the time of my visit, in the winter of 1861, many steps had been formed, but for the rest of the distance I had to make use of ropes and ladders, and to be drawn up by the quarrymen from platform to platform, until, at the height of 400 feet, where a single false step would dash one to the bottom, I arrived at the statuary marble. To this giddy elevation, the legitimate domain of the king of birds, the quarrymen climb like cats, running up ropes until the sight makes one shudder; but M. Sancholle will not allow his men to go anywhere without sharing their danger. By this time most probably the steps have been completed the whole way up. The statuary marble may be extracted in blocks 3 feet thick; it is of a pleasing white, and the structure homogeneous. The hard and very durable blueish ordinary white marbles, being thrown down the precipice, have for some time been conveyed to Seravezza, but the statuary marble is hitherto unknown in commerce. These quarries might truly afford an unlimited supply of marble, as may be imagined, when it is considered that the face presents many millions of square feet.

Continuing our journey to the east, along the ridge of the mountains, we arrive at Monte Corchia, a prominent elevation, presenting almost vertical marble flanks towards the N. and W. The little village of Levigliani, which we pass, lies at the foot of the precipice. Thence we ascend by a very steep horse-track, made by Cav. Simi, the mayor of Stazzema, to his statuary marble quarries. These seem to be within a stone's throw—indeed the marble is slid down the incline (*sdrucciolo*) for a quarter of a mile further—but yet there are two miles of fatiguing ascent before we reach the spot. The succession of the rocks in these quarries in descending order is as follows:—

White marble, forming the mass of the mountain, including statuary marble beds.

Liver-coloured limestone or marble, *persechino*, with black markings, two feet thick, but local.

Ottrelitic breccia, two feet thick, local.

Hard greyish limestone, known as *grezzone*,—considerable beds.

Palæozoic schist and conglomerates, several hundred feet.

Singularly enough, the existence of this marble has only been known of late years. In 1841 a small hole was perceived in the rock close to the base of the precipice, at a spot called the Valle d'Acereto. On examination it proved to be the entrance to a lofty cavern, since called the Grotto of Eolus, penetrating for upwards of 700 feet, the sides presenting at places the most magnificent cascades, falling over fringed stalactites of more than ordinary beauty. On chipping the rock at various points, what was the surprise to find that it was literally statuary marble of the finest kind, and on washing off the slime attaching to the walls at different places they proved to be of the same precious material. Cav. Simi proceeded to purchase the greater part of Monte Corchia, in order to open marble quarries, of which he commenced one on a large scale close to the mouth of the cavern. Having laid out upwards of £3,000 in making the road of which I have spoken, and uncovering the rock, he was rewarded by discovering five beds of statuary marble, and in 1845, according to Pilla, 500 large blocks had already been excavated.

The *persechino* is not a marble which could be obtained in large masses, the total thickness of the bed being so inconsiderable, but as an ornamental stone its novel colour recommends it for internal decoration. The ottrelitic breccia upon which it immediately rests, is a very durable hard stone, which takes a polish; the little olive green or black crystals of ottrelite give it almost a porphyroid appearance.

Proceeding eastward up the Vezza from Seravezza for four miles, we reach Ruosina, passing on the road a multitude of quarries of slate-coloured *Bardiglio* marble, chiefly situated on the lower slopes of the hills. Some is perfectly plain, *bardiglio unito*; when dark, it is known as *bardiglio scuro*; other quarries, near Farnocchia, higher up towards the Monte Matanna, produce a light blue variety, with blackish veins, called *bardiglio fiorito*. These beds have been worked for the last sixteen centuries at least, and, yielding a stone of greater hardness, they are preferred to those of Carrara. Sig. Santini, of the School of Fine Arts at Pietrasanta, informed me that the statues of the "Lion" and the "River" of the Vatican museum, at Rome, which date from the time of Antoninus, are sculptured in Seravezzan *bardiglio*, also two bacchanti found near the ruins of the villa of Quintillius, now in the Palazzo Torlonia. The same marble has been employed in many buildings in Florence.

Above Ruosina, near Ponte Stazzemese, is a little bridge over which we pass to the left bank and ascend the hill to arrive at Pisciarotti quarry, where, above the *grezzone* limestone, comes a considerable thickness of *bardiglio*, only separated from the limestone by a few feet of white marble, so interspersed with talcose veins as to be a species of *madre macchia*. The *bardiglio* can here be obtained of almost any dimensions. The manner in which it is quarried is rather ingenious. Four circular pits, about three feet in diameter, are sunk at a distance of 16 feet apart, so as to form a rectangle. The men stand in the pits provided with a long saw, by which they cut the four faces vertically. After this a groove is cut horizontally at the detached end, and iron wedges driven in; the cleavage is sufficiently distinct for the whole mass to split off in the course of a few minutes. The *bardiglio fiorito* from Pisciarotti, but specially that of Mont' Alto quarry, on the opposite side of the Vezza, are the finest I know of, as may be judged by specimens in the Exhibition. Other quarries of *bardiglio* exist in going towards La Mulina at Fontanaccia, but it appears to be less sound than that from former localities, owing to the presence of minute flaws called *peli*, where the marble is often liable to break off with the utmost facility, much to the annoyance of those who have to work it.

Some of the oldest quarries near Seravezza are those of common white marble (*ordinario*): those of Capella, Solajo, and Ceragiola, already existed in 1353. The marble in this locality has a very decided cleavage, which renders it very easy to form it into small slabs for various purposes. Costa quarry, opposite the town, furnishes a large quantity of marble flagstones for pavements, &c., of which there is an immense trade with Turkey, Spain, South America, the West Indies, and Holland. These flags are cut at the quarry, and polished at Seravezza in revolving mills, termed *frulloni*. Further down the river, Solajo quarry, in the commune of Pietrasanta, produces blueish *ordinario* with large crystalline faces, which stands exposure to the air, and is therefore suited for monuments and for table-tops, but as it does not resist sufficiently well to be able to make sharp edges, it does not answer for fine work.

Below this comes a celebrated ornamental stone, termed *Mischio di Seravezza*, formed from the fragments of rock which have been separated by violence or pressure from the parent mass; these have become subsequently united by a hard cement of amphibole, or specular iron, filling up all the interstices, just as if some semifluid matter were poured over a heap of broken stones by the roadside; the result being a hard, compact breccia, perfectly free from fissures. The paste, when highly ferruginous, tinges the fragments of

white marble of a pale pink; the presence of a large quantity of silicates often renders the breccia very much harder than ordinary marbles. The metamorphic origin of this *mischio* may be studied with advantage by following it northwards to Buca alla vena.

An analysis of the cement made at Pisa by Passerini, gave—

Silica	39·0
Peroxide of Iron	22·0
Alumina	30·5
Magnesia	3.0
Lime	2·0
Water and Loss	3.5
	100·0

The stratification of the marbles is often exceedingly difficult to trace, but in a quarry of *mischio*, opposite Ruosina, it is perfectly evident, the beds being seen resting at a small angle on older rocks. I there observed a block of *mischio*, which had been recently quarried and could not have contained less than 250 cubic feet.

No two blocks of *mischio* are alike, an endless variety of tints and patterns producing a lively effect, especially as it bears a high polish. This stone is very variegated and not suited for anything but internal decoration, the colours being only developed when it is polished.

Some specimens exhibit very nicely the gradual coloration of the fragments of white marble by the ferruginous cement; they are tinged with pink, the colouring matter not, however, penetrating the entire mass, as though the heat had been insufficient to produce an uniform appearance. The result has been a delicate ribbon-like veining, the whole colour of the cement being often communicated to the adjacent portion of the marble so as to obliterate its outline, and gradually softening off till it blends with the pure white towards the centre. Prof. Savi says that the cement contains talc, chlorite, and amphibole. —(*Nuovo Giornale de' letterati di Pisa*, No. 51, 1830.)

The columns of the cathedral of Pietrasanta, made of Seravezza *mischio*, are of the 14th century; but the first particulars we have of the quarries being worked are of the date 1565, when Michaelangelo discovered an eligible place for this purpose, while exploring the Versiglia, by order of Cosmo I., Grand Duke of Tuscany. Vasari was subsequently sent to report on the quality of the stone; his reply being favourable, it was soon largely employed in Florence, as for example the pilasters of the Church of the Annunziata, and the Pitti Palace; for two of the horses and the basin of the fountain of Neptune, on the Piazza della Signoria, in 1563; for the two obelisks on the Piazza Sta Maria Novella. These monoliths contain large masses of white marble, united by a small quantity of purple cement, but they are not good specimens of stone: each is supported by four bronze tortoises, the work of Giovanni Bologna, and surmounted by a bronze giglio, or fleur de lys. Cosmo I. ordered an immense column of *mischio* to be made at Stazzema, but it was broken in the quarry by the fall of a mass of rock.

Cosmo I., having erected a granite column that he had brought from the Thermæ of Antoninus, at Rome, in the Piazza della Santa Trinità, at Florence, in order to celebrate his victory over the banished Florentines in 1537, and another in the Piazza of S. Felice, for the victory of Marciana, proposed to place a third to embellish the city in the Piazza of S. Marco. The marble chosen was Seravezza *mischio*. Almost a volume might be written about the adventures of this block. It entered Florence on September 27th, 1572, placed horizontally, and supported on beams. Its dimensions were 7 feet by 43. Cosmo I. dying, his son, Francis I., ordered the base to be erected, but as the middle support had meanwhile become rotten, it gave way, and the column broke. It was then buried, and in 1661 the base was destroyed to make way for the bridal cortege of Cosmo III. with Louisa of Orleans. In 1694, a priest named Pizzichi, at the head of a number of citizens, brought it to light again, and a base was erected on the same spot as before. It was announced that the column was to be erected to propitiate heaven to give offspring to the ducal house, and a public subscription was set on foot to defray the expenses, but not realising the required amount, the projectors became the object of ridicule. This second base was destroyed in 1731, and employed in the formation of the triumphal arch of S. Gallo, and the column itself was buried in 1757. When examined in 1818, it was found to be so shattered and flawed that it was sawn into slabs and sold. (*Osservatore fiorentino*, tom. ii. p. 114.)

Several beds are formed of marble, with white ground and purple veins; it is commercially distinguished from the *mischio* under the name of *Affricano di Seravezza*. It was employed by Louis XIV. in the construction of the Palace of Versailles, where there may be likewise seen some ornamental tables of the same kind of marble. It also served in making the sumptuous royal monuments in the Medicean chapel in the Church of S. Lorenzo, at Florence. The *mischio* is an excellent stone, and weathers but little.

Repetti (*Sulle Alpi Apuane*, p. 50) gives the specific gravities of the marbles from certain quarries at Carrara, Massa, and Seravezza, the experiments having been made at 8° R. =50° Fah.

CARRARA.

Statuary.		Ordinario.	
Polvaccio	2·631	Ravaccione	2·597
Mossa	2·598	Fossa dell' Angiolo.	2·594
Zampone	2·587	Canal Bianco	2·589
Betogli, 1 year after quarrying	2·586	Fantiscritti	2·584
Ditto, 3 years after quarrying	2·581	*Bardiglio.*	
Poggio Silvestro	2·581	Zampone	2·689
Crestola	2·580	*Madri Macchie.*	
		Zampone	2·644

MASSA.

Rocchetta	2·595
Saineto	2·593

SERAVEZZA.

Monte Altissimo	2·584

Number of Persons employed in the Marble Trade at Seravezza, Jan. 1, 1862.

	Number.	Number who are able to read.
Master quarrymen	80	70
Quarrymen	400	100
Men employed in shaping the blocks	350	100
Men employed in making flagstones	100	65
Workmen in the marble works	100	80
Waggoners	78	20
Number of persons depending on the above for their sustenance, wives, children, &c.	3,000	600
Total	4,108	1,037

Number of Marble Quarries at Seravezza, kindly furnished by the Mayor.

Year.		
1800	(about)	15
1815	,,	20
1830	,,	40
1845	,,	60
1860	,,	75

4. Vagli-Sotto.

Passing over to the north flank of the Apuan Alps, and proceeding from Monte Corchia, the white marble beds extend in the direction of Monte Tambura. About half way to Arni, on the right bank of the Canale della Campanice, on the flank of Monte Serra, is the Campanice quarry, where Sig. G. Santini, of Seravezza, has discovered extremely good fine-grained marble, with the pearly lustre of boracic acid crystals. A little lower down the valley is the Crocicchia quarry, where similar statuary marble occurs, as also white ordinary. The quarries cannot be worked, from the entire deficiency of roads; and here I would ask whether the Italian Government would not do well to assist in constructing the highly important road projected from Ruosina to Castelnuovo di Garfagnana, which, passing by this place, would facilitate, in no small degree, not only in procuring the poor villagers the means of sustenance, but also would open out a very considerable trade.

Other localities in this commune furnish white marble; thus, the line of mountains, from the Altissimo to the Tambura, throughout the whole valley, from Arni to the Serra, is strewed with blocks fallen from above. The east flank of the Tambura, along the horse-track from Vagli-sotto to Massa, is almost a mass of crystalline white marble, although, by exposure to the sun and frost, it has become much crevassed and injured. Some is excellent fine-grained statuary, and in ascending to the Buca dei Gracchi, close to the pass of the Tambura, it assumes a ceroid structure near its contact, with dark bituminous limestones, traversed with white veins. The old complaint—want of roads—has crushed all enterprise in this part.

The following is a list of places where marble exists in the commune:—

Statuary, Ripanojo, Serra di Mezzo, Campanice, and Crocicchia.
White marble, Serrone.
Dark *bardiglio*, Ripanojo.
Blueish grey *mischio*, Serrone.
Mischio, Arnetola.

Marble is likewise found in the following localities on Monte Tambura:—La Fossa, Serra del Cavallo, Picco del Matteo, Penna di Campo Catino, Rocca in Dagio, Boschetto, Fossa di Romigiaja, Carpinaccio, Canale dell'Arco, Canale della Fariaccia, Pitone dell'Aquila, Casino, Serrone, Fosso di Colle Ebraio, Bagnoli, Fontana fredda, Calcinaccio, Portaccia, Macchione, Alboretti, Alto di Sella, Poggio del Bernardino, la Fontanella, Monte Somoro.

5. Fivizzano.

We followed the mountains at Carrara as far as Monte Sagro, which on the south overlook Massa and Carrara, and to the north is connected with the Pizzo d' Uccello, a lofty mountain the culminating point of a short spur terminating abruptly near Equi and Ajola, at the valley of the Lucido. White marble beds extend throughout the whole of these mountains, although the fact seems only known to the inhabitants and a few Italian geologists. Not a single quarry exists on the territory of Fivizzano, although a close examination of the rocks will prove to anyone that the same quality of marble may be obtained here as at Carrara. The broad valley of the Lucido has a powerful mill stream, which would afford great facilities

for sawing; a tramway or common road could also be very easily made along the banks of the Lucido to its junction with the Magra, and thence to meet the intended Genoa and Pisa railway near Spezia.

One of the torrents descending from Pizzo d' Uccello towards the north, before debouching into the valley, passes through a grand and most picturesque gorge, with vertical limestone walls several hundred feet high, known as the Solco d' Equi. This chasm is many hundred feet long, and not more than 50 wide, and although, from its inaccessible position, not mentioned in any guide book, it contains, to my mind, some of the finest scenery in Central Italy. The origin of this gorge may probably be ascribed rather to a rent in the mountains during the act of upheaval than to the power of the torrent, as it lies north and south in the direction of the strike of the beds. Having entered between this wall of rocks the little valley opens out, and from this point to the Pizzo d'Uccello, white marble might be quarried with the greatest ease. Veined white marble exists in large quantities at La Colazzola, and with some quarrymen furnished me by Avv. Cojari, of the Massa Sub-Committee for the Exhibition, I succeeded by blasting in finding a very nice bed of statuary marble at a spot known as Ai Marmoli.

Another locality where statuary marble occurs is on the Monte della Campana, half way between Vinca and Ajola, where a precipice of 400 and 500 feet overhangs the mountain path. Not many steps from this is the Canal del Piro. The summit of the hills at the head of this valley is white marble. No person could mistake the characteristic appearance presented by the marble on the western flank of this mountain. The cleavage runs from north to south, and from north-west to south-east, and the action of frost and heat has been to enlarge these minute fissures, and detach pieces from the rock, so that the mountain side looks something like parallel series of gigantic biscuits placed side by side. At one spot, where I blasted away this weather-worn stone, I found underneath the very best hard and homogeneous blueish ordinary marble, suitable for all kinds of architectural purposes.

White and red and *bardiglio* marbles also occur at Tenerano, N. of Monte Sagro, but are not worked.

The mountains above Vinca contain large quantities of a very delicate pink and white breccia, different from any found on the Carrara side, which would form an ornamental stone of great beauty for internal decoration.

6. Sarzana.

Before quitting the subject of the Apuan Alps, it will be necessary to glance at the structure of the rocks at the Bianca, at Cape Corvo, the southern point of the Gulf of Spezia, described by Sir Roderick Murchison and Sig. Cocchi. The white crystalline marble offers itself in a most tantalising manner in the cliff on the very margin of deep water, but in very small quantity, traversed in every direction by iron veins, converted into carbonate at the surface where exposed to the atmosphere, so that unfortunately not the smallest block of pure homogeneous marble could be obtained. The connection between the metamorphic marbles of Cape Corvo and the intrusion of an immense dyke of magnetic or specular iron, similar to that of Elba, seems to be very apparent, nor is any spot better situated than this for studying the formation of marble.

The inhabitants of Luna employed this marble as a building stone, and many fragments of it are to be picked up among the ruins, but I can by no means agree with Bertolani that the entire walls were made of Cape Corvo marble, for, had they been so, they would scarcely have inspired Ciriacus Anconitanus with the lines I have quoted describing their snowy whiteness.

General Remarks.

All along the streams, at Carrara, Massa, and Seravezza, are numerous water-mills, where the blocks are sawn into slabs for table-tops, and the smaller pieces made into squares for pavements, &c.

All the sawing frames at Carrara, Massa, and Seravezza, are set in motion by water-power. At some mills I have seen even within the last year, mechanism of the rudest possible kind, consisting simply of a rectangular wooden frame (*telajo*), with iron blades, a pair of frames being attached eccentrically by a wooden rod to a small water wheel. This primitive and almost barbarous method has been generally superseded by far more complicated and better machinery; in such mills the frames are suspended by chains at each angle from a second rectangular frame at the height of about 10 feet, supported on 4 posts. The saws are simple iron blades, 9 or 10 feet long; 18 to 24 are fixed into a massive rectangular wooden frame, generally at intervals of an inch; thus a large block of marble is at once cut into numerous slabs. Several sawing frames are placed parallel to one another, and perpendicular to the axis of a wheel, to which they are attached by a connecting-rod, motion being communicated by an eccentric. The saws descend gradually as desired, by means of a rope passing round a wooden cylinder, with a stone counterpoise at the end; the motion of the water wheel is connected by gearing with the main shaft, on which work drums corresponding to each frame. The connecting rod of the frame is placed eccentrically on a drum working together with the other by means of a belt. A

fly-wheel is generally added to regulate the speed of the frames. Much attention is required on the part of the workmen to watch the saws day and night, otherwise they would not act properly. A pile of sand is placed on the blocks of marble, and, aided by a small jet of water, finds its way gradually between the cuts produced by the saws; but it acts very irregularly, for sometimes there is too large a proportion of sand, while at other times the water is superabundant and washes it away. Occasionally a second connecting rod is placed at the further extremity of the frame, to unite it with another frame. All these are very old contrivances, although they work well, for whereas only 25 per cent. is available in the first described frames, by these an actual force of 75 per cent. is obtained. Two or three horse-power is required for every frame. To make three-feet vertical cuts in a block of ordinary white marble take from 4 to 6 days and nights. Sig. Vannucci's mills at Corvaja, near Seravezza, have wrought-iron frames weighing upwards of a ton each, and which are probably preferable to wooden ones. M. Sancholle Henraux has very good, well-planned mills at Seravezza; he distributes the water with great regularity by mechanical contrivances over the whole width of the block, upon which it trickles by gentle drops. The descent of the frames is also managed without the rope and counterpoise, by employing cog-wheels and rachets.

M. Henraux, to show the excellent nature of his sawing mills, exhibited at Florence a couple of slabs of veined white marble, only an inch thick, 11 ft. 4 in. by 6 ft. 2 in., or upwards of 70 superficial feet.

Count Guerra has some highly interesting lathes at his mills at Massa, for turning marble; he is also fitting up some machinery of his own invention for simultaneously boring and cutting concentric marble cylinders of any size, without loss of material. This establishment is unique in its kind, and well worthy of a visit. The principle of forming hollow cylinders is very valuable in diminishing the price of marble pedestals, bases, &c.

Of all the mills at Carrara, that of Mr. Walton, the British consul, bears the palm; he has erected a spacious building for 12 sawing frames, of which only 6 are yet erected. Each of these frames receives its motion by a connecting rod, attached to a drum revolving with the main shaft running along the whole length of the building, and furnished with a fly wheel. The sawing frames swing backwards and forwards, supported by chains, but it is intended to replace them by rigid iron rods, so as to give a species of pendulum motion. The frames are suspended on a cast-iron framework, supported by four columns; their motion is very steady, as they are provided at each corner with a guide running in a groove in the columns. The saws descend by themselves by means of gearing provided with a tooth-wheel and rachet, receiving its motion through a connecting-rod attached eccentrically to the fly-wheel. The travel of the connecting-rod can be regulated at will by running it along the slot. Chains pass over pulleys at each angle of the iron girders, whence they descend to corresponding angles of the sawing frame. A worm and wheel gearing sets in motion a finely-fluted iron cylinder, placed transversely on the frame, and supplied with sand falling from a hopper above. A stout iron rod revolves in immediate contact with the cylinder, just above its axis, in order to push back the whole of the sand but what lodges in the flutings, and which is carried round. A series of minute jets of water are here projected upon the cylinder, to wash off the remaining sand, which falls in a regulated manner on the block of marble below, like a fine shower. The hopper is only filled once in 12 hours, so that the labour is next to nothing. The oil for the bearings is placed in Coquatrix's patent oil-cups, manufactured at Lyons. This ingenious little contrivance consists of a small glass, with metal cover, and provided with a screw running through its axis; the oil passes through a slit in the screw; the size of the aperture can be adjusted with the utmost nicety by turning the screw, not a drop going to waste or being able to fall upon the marble, which it would inevitably destroy—a decided improvement on the former methods. In addition to the economy, such is the cleanliness, that machinery might be worked on a drawing room carpet, without risk of smell or soiling the furniture.

A travelling crane moves on a railway placed under the roof in the direction of the building, and serves or loading for unloading the blocks from the ox waggons. While being sawn the blocks are placed on carriages running on rails transversely to the mill, and passing under each sawing frame.

Mr. Walton does not employ a vertical wheel, like the other gentleman, but a turbine of about 50 horse-power, which sets in motion the main shaft. The fall of the water is not very great, but the mill stream is a powerful one.

No vessel can load at the beach below Massa or Seravezza direct for this country, as the depth of water is so inconsiderable, though coasters go as far as Naples, Marseilles, Genoa, and Leghorn.

Mr. Walton is well known to have achieved a great work in having built a pier or jetty at the Marina di Carrara, in 1854, for shipping blocks of marble. This was necessitated by the flat nature of the coast, where otherwise boats have to be drawn up on the beach, and the blocks hoisted up between three poles fixed on the sand, serving as a crane. When the feluccas are laden they are

launched on greased poles placed athwart. The difficulty, however, increases in the case of large blocks; for instance about 30 years ago two immense masses of marble, intended for collosal statues to be sent to Rome, were loaded in a felucca drawn up on the beach and then filled with sand; a gentle incline plain was made on either side of the boat, and the blocks carried over it in the ox-waggons themselves; after this the sand was shovelled out, and she was hauled down to the sea. Mr. Walton's pier is now 900 feet in length, and entirely built of creosoted piles 40 feet long. This, however, has been insufficient to protect it against the ravages of the teredo, the piles becoming rotten; I have seen many of them which had snapped off at the level of the water, like touch-wood. They have lately been protected by scupper nails. A tramway runs the whole length of the pier, the trucks being loaded directly from the ox-waggons. Three cranes, two of 8 and another of 20 horse-power, are provided for the convenience of loading vessels, so that 400 tons may be loaded daily. The beach presents a sight rarely equalled; last winter there were about 20,000 tons of marble, worth at least from £80,000 to £150,000, lying about, ready for shipment. Mr. Walton has raised the trade of Carrara very considerably. While American consul he almost originated that with America, now so extensive as to have far surpassed the trade with England, chiefly consisting of white marble, for monuments and architectural decorations. Singularly enough, great as is the quantity, the marble preferred for the American market is of the worst description, being, in fact, almost what would be considered rubbish in other countries.

An efficient mode of sawing blocks *in situ* is much to be desired. The extensive use of gunpowder is wholly unsuited to the getting out of the stone, as the rock is already frequently much shattered. Hitherto it has been the custom to extract the marble only at or near the surface. I doubt whether the white kinds would not be obtained better by cavern working, by which means it would be far less exposed to the action of the atmosphere and to variations of temperature, which must considerably augment the tendency to shiver, water enlarging and extending almost imperceptible flaws as it freezes in winter or evaporates in summer. I had occasion, for this reason, to suggest to Cav. Simi, at Levigliani, the extensive extraction of statuary marble in the interior of the grotto d'Eolo.

Previous to 1809 no road existed between Carrarra and Lucca. In this and the following year it was constructed by Elisa Baccicchi, the sister of Napoleon, then Duchess of Lucca. She also about this time drained the lake of Porto, near Montignoso, and placed floodgates to prevent the salt water from entering: by this means the country can now be traversed without fear of catching fevers from malaria, which formerly prevailed to such an extent in these *maremme* that they were nearly depopulated.

At Seravezza, road communication is established as far as Ponte Stazzemese up the Vezza; elsewhere, I am sorry to say, the means of transit cannot be spoken of very favourably; blame is not to be laid on private individuals, but to be ascribed to maladministration of late Governments, especially that of Modena. Under the wiser rule of the new sovereign we may hope for better results. Hitherto the argument of Cosmo I. has been considered convincing, who having commenced an enormous obelisk near Seravezza, some one inquired of him how it should be transported to Florence? "Let us first think of quarrying it," replied he, laconically, "and then how we may manage to bring it here."—(*Agostino del Riccio.*) The true motto should be, "Make your communications—quarries will soon be found to line the road."

The railway from Genoa to Pisa will pass near Carrara, Massa, and Seravezza; and, as I proposed three years ago, I should recommend a system of tramways down certain valleys (as I have drawn on the accompanying map), instead of an apology for an ox-track, which now leads from Carrara and Seravezza to the most celebrated statuary quarries in the world On the Modena side this could be done without trouble. I would suggest that the Government should concede to the three towns of Massa, Carrara, and Seravezza, the right of making a perfect set of tramways from the main railway stations to the mountains, and that the proprietors of the quarries should be compelled to make use of the tramroad, for which they could annually compound for a certain sum. By this means the antediluvian form of ox-waggons would be done away with entirely; and instead of feluccas below Carrara and Seravezza having to put off from the beach, as is now the case, whenever the wind sets on the exposed shore, thereby often incurring months of delay and much expense, the whole of the marble would go by railway to Spezia or Leghorn, where the ports are always accessible. By these simple tramways, constructed at a sufficient height above torrents, communication would be permanently established with the towns; and, without diminishing the profits of any of the proprietors, marbles could be obtained at a far lower price, and this would ensure an increased consumption at home and abroad.

The exports of marble from Carrara, from 1837 to 1846, were valued at £370,341. The total produce in 1847, including that for home consumption, was estimated as worth £66,139. At the same period, 2,258 persons

SHIPMENT OF MARBLE IN BLOCKS FROM THE BEACH AT CARRARA, 1853-1857, DRAWN UP BY MR. WALTON.

DESTINATION.	1852.	1854.	1855.	1856.	1857.	Total.	Mean.
	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.
Leghorn...	19,735	30,660	22,495	25,930	24,336	123,156	24,631 1/5
Genoa	8,046	10,829	7,139	6,068	3,432	35,514	7,102 4/5
France direct	2,897	3,863	4,260	5,087	5,170	21,277	4,255 2/5
Tuscany, kingdom of Naples, Spain, Papal States, &c.	952	2,200	2,806	1,550	1,725	9,233	1,846 3/5
Annual totals	31,630	47,552	36,700	38,635	34,663	189,180	37,836

TABLE,

Showing the ultimate Port of Destination of the Carrara Marble shipped to Leghorn and Genoa.

PORT OF DESTINATION.	LEGHORN.					GENOA				
	1853.	1854.	1855.	1856.	1857.	1853.	1854.	1855.	1856.	1857.
	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.
Amsterdam	500	710	725	840	810	15	6	51	...	...
Antwerp	670	1,485	1,110	1,395	1,780	555	339	366	320	60
Baltimore	...	310	550	...	886	...	...	...	569	...
Barcellona	...	...	...	...	...	6	12	162	2	15
Boston	865	2,480	1,520	3,490	1,380	...	...	...	633	127
Bristol	205	400	325	440	245	...	...	...	...	...
Buenos Ayres ...	...	...	...	...	...	...	144	126	10	25
Cadiz	...	...	...	...	...	96	...	144	10	21
Calcutta	...	...	...	...	...	...	78	...	...	...
Cork	840	185	80	80	...	...	...	...	...	...
Cronstadt	170	340	...	380	570	...	...	...	...	...
Copenhagen	...	...	...	...	80	...	...	...	...	...
Carlisle	...	100	...	...	...	...	...	...	...	...
Dublin	40	320	355	80	220	...	...	...	...	...
Dunkerque	...	270	280	...	...	...	...	...	120	...
Falmouth	35	...	...	40	...	...	...	...	...	...
Glasgow	210	320	165	100	340	...	...	...	...	...
Hamburgh	85	185	750	600	440	159	213	327	...	...
Havannah	...	...	...	...	...	...	129	39	6	1
Hull	...	85	...	170	...	...	...	...	...	...
Leith, Edinburgh ...	...	...	120	30	80	...	...	...	...	...
Lima	...	...	...	...	...	...	...	...	12	...
Lisbon	...	...	...	...	...	...	...	...	30	19
Liverpool	1,085	1,515	1,310	1,670	1,725	...	...	...	75	...
London	4,200	5,687	5,355	3,135	2,855	...	174	189	357	504
Mobile	...	...	...	...	...	...	...	...	44	48
Monte Video... ...	...	...	...	...	...	...	117	219	...	36
New Orleans... ...	...	...	...	...	...	...	186	210	588	659
New York	9,485	13,333	9,165	11,790	10,010	1,089	2,727	1,143	2,288	386
Odessa	...	...	...	...	...	18	...	...	10	5
Philadelphia	1,275	2,835	600	1,400	2,075	153	222	636	250	234
Piedmont & Lombardy	...	...	...	...	...	5,955	6,143	3,284	690	1,227
Rouen	...	100	...	250	495	...	...	...	...	...
Rio Janeiro	...	...	...	...	...	...	300	200	6	...
Rotterdam	70	...	85	...	150	...	39	43	78	65
Stockholm	...	...	...	40	125	...	...	...	...	...
St. Petersburg ...	...	...	...	...	70	...	...	...	...	...
Annual totals ...	19,735	30,660	22,495	25,930	24,336	8,046	10,829	7,139	6,068	3,432

PRODUCTION OF MARBLE AT CARRARA AND MASSA DI CARRARA,

DRAWN UP FROM OFFICIAL DOCUMENTS, BY SIG. GRASSI.

The upper line in each square gives the production of Carrara, the lower that of Massa.

QUALITY.		1838.	1839.	1840.	1841.	1842.	TOTAL. 1838–1842.	1854.	1855.	1856.	1857.	1858.	TOTAL. 1854–1858.	
		Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.
Sculpture		61	50	81	59	52	303	94	99	90	81	77	441	449
		...	1	...	1	...	2	...	...	...	6	2	8	
Architectural Pieces	Smooth	1,050	1,232	1,326	1,133	1,183	5,924	786	932	827	803	1,130½	3,478	3,874
		2	3	8	8	3	24	7	54	64	95	176	396	
	Ornamented ...	43	56	21	40	61	221	72	17	41	36	80	246	269
		...	...	...	...	3	3	12	11	...	...	...	23	
Flags for Pavements		973	913	653	639	616	3,794	1,074	1,003	878	871	873	4,699	7,052
		6	55	34	14	14	123	604	757	625	667	700	3,353	
Mortars		36	21	22	59	108	246	137	196	157	145	108	743	748
		...	...	...	1	2	3	1	...	4	...	..	5	
Slabs		—	—	—	—	—	—	127	107	212	264	103	813	4,999
		24	29	22	41	18	134	50	294	1,536	1,229	1,077	4,186	
Tables, &c.		709	636	645	667	811	3,468	1,558	1,945	1,686	1,877	2,096	9,162	13,187
		2	13	23	17	30	85	903	946	741	736	699	4,025	
In blocks	Statuary marble ...	1,127	1,189	1,520	1,300	1,203	6,339	1,611	1,497	1,327	1,552	1,052	7,039	7,345
		57	33	3	19	5	117	31	44	69	79	83	306	
	Veined Statuary Marble	...	...	...	...	...	...	439	564	565	560	1,174	3,302	3,459
		...	...	...	...	...	...	34	33	29	18	43	157	
	Veined ordinary Marble and *Bardiglio*	7,677	8,550	9,286	1,694	9,064	36,371	49,651	30,159	30,519	33,603	32,919	176,851	186,990
		95	54	119	...	30	298	2,937	1,610	1,720	1,598	2,274	10,139	
TOTAL	Carrara	11,676	12,747	13,554	11,591	5,098	56,666	55,549	36,519	36,302	39,792	39,612	207,774	230,372
	Massa	186	188	209	101	105	789	4,579	3,749	4,788	4,428	5,054	22,598	

were employed, directly or indirectly, in the marble trade.—(*Annuario Economico Statistico dell 'Italia, Torino*, 1853.

Mr. Walton assured me that it might be calculated that about £6000 were paid weekly at Carrara to artists, sculptors, quarrymen, boatmen, and drivers, connected with the marble trade, a sum not less than £300,000 per annum.

Of the marble in blocks about half is exported to the United States, which, until the outbreak of the civil war, was a steady and good market. Of the other half one-third is exported to Great Britain, and two-thirds to the rest of Europe. A heavy duty is levied on Italian marbles in France, in order to keep up the demand for home produce. Notwithstanding these disadvantages, Carrara marble is much used there. The weight of Carrara marble is about 160lbs. per cubic foot. That of Sienna marble is about 180lbs.: it is sold by weight. The price of labour at Carrara is about 2s. per diem for common labourers; 2s. 6d. to 3s. for skilled quarrymen; 4s. for the best and most intelligent workmen.

As we obtain all the marble *viâ* Leghorn, the Custom-house returns which I here append do not specify which is Carrara produce and which is really Tuscan marble.

IMPORTS OF MARBLE FROM TUSCANY—(INCLUSIVE OF CARRARA MARBLE):—

Years.	Sawn or otherwise manufactured.		Value.	Rough blocks or slabs.	Value.
	Tons.	cwts.	£	Cubic feet.	£
1854	443	3	11,079	106,601	66,627
1855	265	19	7,979	99,231	54,577
1856	514	14	20,988	56,804	31,242
1857	491	0	19,640	84,524	46,488
1848	515	16	29,288	68,553	37,704
1859	593	12	29,678	89,740	49,358
	2,904	4	118,652	505,453	285,996

AVERAGE PRICE OF THE VARIOUS KINDS OF MARBLE AT THE BEACHES OF CARRARA, MASSA, AND SERAVEZZA.

69 CUBIC GENOESE PALMS, OR 35·317 ENGLISH CUBIC FEET=1 CUBIC METRE.

QUALITY.	Per English cubic foot.				Per cubic Genoese palm.		
	s.	d.		s.	d.	Francs.	
Statuary, small pieces	17	6	to	23	6	11·20 to	15·00
,, larger pieces	23	6	—	31	3	15·00 —	20·00
,, very large blocks, up to			—	47	0	—	30·00
Veined statuary	4	3	—	5	9	2·75 —	3·75
Architectural white, *bianco chiaro*	4	8	—	7	10	3·00 —	5·00
Best Falcovaja, *bianco chiaro*	7	10	—	12	4	5·00 —	8·00
Veined white	3	10	—			2·50 —	
Spotted white, Massa	3	10	—			2·50 —	
Ravaccione, Carrara	3	1	—	4	8	2·00 —	3·00
Common white, Solajo, Trambiserra	2	7	—	3	3	1·68 —	2·10
Bardiglio	3	6	—	6	2	2·25 —	4·00
Flowered *bardiglio*, Stazzema	7	10	—	12	10	5·00 —	8.40
Paonazzo, Carrara			—	8	10	—	5·60
Persechino, Levigliani			—	7	10	—	5·00
Mischio, al Ficale, Massa, about			—	15	8	—	10·00
Seravezza, *mischio*	16	4	—	18	10	10·50 —	12·00
Affricano breccia, Stazzema...			—	26	4	—	16·80
Stalactitical marble, Nido del Corvo, Massa ...	6	2	—	23	6	4·00 —	15.00
Portoro, best veined, Spezia			—	10	3	—	6·50
Common *portoro*, Spezia			—	7	10	—	5·00
Black marble, Spezia			—	4	8	—	3·00
Biassa breccia, Spezia			—	7	0	—	4·50
Coregna breccia, Spezia			—	26	7	—	17·00
Marble baths cost at the beach at Carrara, from ...	114	0	—	118	0		
Statuary marble sells at Paris for			—	68	5	42 or 2900 per cubic mètre.	

PRICE OF MARBLE SLABS AT SERAVEZZA.

QUALITY.	Per square foot.	Per square palm.
	s. *d.*	Francs.
White marble	0 $6\frac{1}{2}$	0·40
Bardiglio	0 $7\frac{3}{4}$	0·50
Flowered *bardiglio*	0 10	0·65
Statuary	1 $3\frac{3}{4}$ to 1 $11\frac{1}{2}$	1·00 to 1·50
Mischio	1 $3\frac{3}{4}$	1·00

The prices of marble in London fluctuate. Sig. Fabbricotti has informed me that they are about as follows:—

	Per cubic foot.
Superior statuary marble fetches as much as	£3 0 0
First quality	£1 15 0 to 2 0 0
Second quality	0 16 0 to 0 18 0
Common white, called in England, for some unaccountable reason, "Sicilian"...	0 7 6 to 0 9 6
Veined white, *Bianco chiaro*...	0 8 0 to 0 10 0
Carrara "Dove," or *Bardiglio*.	0 9 6 to 0 11 6
Seravezza "Dove," or *Bardiglio*	0 11 6 to 0 16 0
Portoro "Black and Gold" ...	0 14 0 to 0 18 0
Paonazzo	0 14 0 to 0 15 0
Sienna yellow marble	1 12 0 to 2 0 0

LA SPEZIA.

I KNOW of no Oolitic marbles in Tuscany; but to the Cretaceous period belongs the celebrated and widely-used *Portoro* of the islands of Tino and Palmaria, and the western promontory of the Gulf of La Spezia (*Genoa*), near the ancient confines of Modena and Piedmont .The village of Porto Venere, opposite Palmaria, bombarded during late wars, and still half in ruins, is of great antiquity, having been known to the Romans as *Portus Veneris*. I should imagine it highly probable that the Romans employed the beautiful marbles near this place, though Targioni asserts that the quarries were only discovered at the beginning of the 16th century. In 1823 only two quarries were at work, producing about 8,000 cubic *palmi* (4,100 cubic feet) at 6 francs per *palmo*, or 48,000 francs. (Guidoni; *Osservazioni geognostiche e mineralogiche sopra i monti che circondano il golfo della Spezia*, 1827, p. 29.)

The strata extend from Tino through Palmaria, where there is also a quarry, to the promontory as far as Castellana, near Campiglia. The marble is chiefly black, but some beds contain bold golden yellow veins of the greatest beauty, which come out equally well when cut in the direction of, or normal to, the strike. It takes an excellent polish, and is one of the best coloured marbles known, and all the more valuable as blocks can be obtained *of very* considerable length. A great convulsion which has occurred here, and which has been so ably described by Sir Roderick Murchison, may now be more easily studied than formerly, for half way to La Spezia, and near the newly-erected arsenal, is a lofty conical hill, crowned with a fort; the strata have been laid bare from the base to the summit by the engineers, who are constructing a military road up the hill. Seldom does the geologist find natural sections so admirably supplemented by human art as here, where the strata of hard limestones verging on marble are seen alternating with thin beds of softer rocks, and the violent upheaving power may be traced to perfection; in one part of the valley they form a large synclinal axis, the strata inclining on either side at an angle of 60° with the horizon; further down, the distortion increasing, the lower beds are actually turned over on the upper.

Several kinds of marble are found near Spezia, which are little known in commerce; thus, about half a mile west of the town and directly N. of Castellana is the quarry of COREGNA, where a magnificent and varied breccia occurs at the junction of the marble beds above described, with the grey dolomite.

This breccia seems to be evidently the result of metamorphic action, for the wine-red ground is nothing but schist, apparently indurated by heat, and forming a paste in which are embedded fragments of crystalline white marble—*bardiglio* and *portoro*. The paste might almost be called *gabbro rosso*. It is considered by Cocchi to be of Tertiary origin. Few stones are better adapted for internal decoration, as it takes a beautiful polish, but it is excessively hard to quarry. This marble re-appears in several places, following a line N.N.W. in the direction of the strike of the beds.

At BIASSA, 5 or 6 miles N.W. of Spezia, is a quarry of breccia, the fragments being of brownish-white, imbedded in a wine-red cement. The beds are collectively about 40 feet thick. It may be procured in large masses, but is difficult to obtain sound, as certain flaws run through the rock. There is no road within a couple of miles.

MONTI PISANI.

In the Pisan hill most of the Tuscan rocks, as Prof. Meneghini observes, are represented in miniature. Some of the lower liassic limestones have there also been converted into ceroid white marble, sometimes containing metamorphosed fossils, probably *Pleurotomaria*, but never into statuary, for the structure is nowhere saccharoidal; nor do *madrimacchie*, the unvariable accompaniments of statuary marble in the Apuan Alps, ever occur here. The quarries are on the southern slope, at Bagno della Duchessa, near Asciano. This marble is not so sonorous as that of Carrara, although polishing tolerably well; it is probably derived from a more impure marly limestone.

Many of the ancient churches and public buildings of Pisa, as recorded by historians, are constructed of this marble. The celebrated Campanile, or leaning tower, built by Wilhelm von Innspruck and Bonnanno Pisano, in 1174, is of Pisan white marble. This remarkable building has undergone considerable restoration at different times during this century, so as to look very fresh; in many cases entire columns have been removed, and substituted by new ones; the marble employed for this purpose is that of Seravezza.

The marble columns of the Campanile, as well as the rectangular blocks which unite them to the tower, have suffered much from the effects of the *Libeccio*, a moist sea breeze common on this coast.

To explain this action it is necessary to remark that the Mediterranean may be compared to a vast evaporating pan, for, as is well-known, the current at Gibraltar always sets *inwards*, while, on the other hand, numerous large rivers discharge themselves into this sea at many points. Thus, having no exit for the waters, it contains a far greater proportion of salts in solution than the ocean, and the sea breezes are charged with a considerable quantity of mineral matter, which is deposited on the cold surfaces of buildings, &c. Every one who has been at Pisa may have often observed that when the *Libeccio* prevailed, even during the day time, and although the sky may have been perfectly clear, the marble pavement around the cathedral, and the flagstones on the Lungo l'Arno, were bathed with moisture, as if a heavy dew had fallen.

When the sun shines the salt concentrates, until it becomes a saturated solution; the process of destruction of white marble then proceeds slowly but irresistibly. The salts (chlorides of calcium, magnesium, &c.) act upon the marble (carbonate of lime); a double decomposition ensues, resulting in the formation of two soluble products at the surface of the stone, viz., carbonate of soda and chloride of calcium. The former may be seen in the Campanile as a copious efflorescence at the joints, and incrusting the parts sufficiently sheltered as not to be washed off by the rain; the chloride of calcium works its way between the crystalline particles of the marble below, which it serves to disintegrate to the depth of a quarter of an inch. In process of time the surface of the stone becomes covered with an intensely white pulverulent marble, easily detached with a knife. The marble so disintegrated is termed in Tuscany *cotto* or *calcinato*, that is, baked or calcined.

The erosion of the marble only takes place on the side exposed to the sea, so much so, that while on that side some of the architraves of the Campanile have been eaten out to the depth of six inches, and many of the columns have had to be replaced by fresh ones in consequence, on the land side of the building there is not a trace of decomposition to be observed throughout the entire height.

The tower itself has not suffered nearly so much as the columns. Some of the restoration has been of yellowish-grey limestone from the Pisan hills. Singularly enough, the corrosive action has been far more powerful here upon the cement of the *Verrucano* siliceous conglomerate blocks, which are often eroded to the depth of 3 inches, both inside and outside the tower, and assume the most fantastic forms.

The greater part of the Duomo, and much of the Baptistry, are also of Pisan marble, but along with them numerous ancient stones, brought in the Pisan vessels from foreign parts, have been built into the walls of the cathedral, the inscriptions being still legible on them.

The Upper Liassic *mischio* of Sta Maria del Giudice has been extensively worked of late by several proprietors. Cesalpino states that the façade of the baptistry of Pisa is of this breccia; it is white, veined with yellow.

At la Duchessa, at Agnano, is a quarry of jet black marble. This is rather rare in Italy.

Prof. De Luca, of Pisa, found, by some interesting experiments, that the black marly limestone of the Monti Pisani, treated with hydro-chloric acid, dissolved very slowly, and contained such a large quantity of carbon that it remained behind as a spongy mass, retaining the original form. This must not, however, be confounded with the true black marble of Agnano.

Monte Pescaglia, in the Monti Lucchesi (*Lucca*), furnishes a marble of the same age (Neocomian), and very similar to the *portoro* of Spezia; that is, black, with lively flesh-coloured pink or grey streaks and veinings, combined with calcareous spar.

CAMPIGLIA.

At Monte Rombolo, near Campiglia, in the Maremme (*Grosseto*), both statuary and ordinary white marbles are found, belonging to the same geological formation as those of Carrara. There are four quarries of statuary,

Grechetto, Giove, Pario, and Medici; but, owing to the difficulties of transport, neither of them is worked. The grain of Campiglian marble is, in general, larger and more lamellar, and the colour purer white than that of Parian marble, which it very much resembles, but from which it may be distinguished by not giving that bituminous odour, when subjected to friction, which the latter emits in common with most Greek marbles. The most ordinary observer, on the other hand, would recognise the difference between the lamellar structure and pearly lustre of the Campiglian marble and the fine grain of that from Carrara or Seravezza.

We know that the Romans worked the quarries of white marble near Campiglia, for, in this neighbourhood, it served to make their milestones on the Emilian way, which connected Rome with Pisa; some of these milestones are preserved in the magnificent collection at the Campo Santo at Pisa. Cosmo I. also employed Campiglian marble for the Cathedral of Sta Maria del Fiore, at Florence, for which it was used in greater quantity than that of Carrara, both to inlay the walls and ornament the celebrated dome of Brunelleschi.—(Ripetti, *Dizionario*, tom. 1, p. 421.)

The *Bardiglio* accompanying these white marbles can be at once distinguished from all those at Carrara and Seravezza, both by its greyish-blue tint and white markings, and its lamellar crystalline structure, the *bardiglio* from the other localities being a compact marble.

ELBA.

In Elba (*Leghorn*), pure white marble is found at Cape Ortano, where the ancients had quarries, taking advantage of its proximity to the sea. The grain is very lamellar, resembling Parian marble; the quarry was re-opened by Napoleon, while exiled in Elba; that great genius at once saw the excellence of the stone, but since his departure no one has followed up his wise example. Surely this has been a great oversight. White crystalline but very impure marble also occurs at Valdano, near Portoferrajo; it is not to be recommended.

MONTAGNUOLA SENESE.

I will now pass to the Senese (*Sienna*). In going from Sienna to Massa Marittima the road follows a south-westerly course; after proceeding eight miles, and having reached the village of Rosia, we finally quit the Tertiary formations, on entering a narrow gorge between two hills, and ascend for two miles the Rosia, a rivulet which debouches at the eastern end in the Merse, a branch of the Ombrone. A fault is to be noticed near Rosia; the rocks have been much upheaved, disclosing the Palæozoic strata, consisting of quartz pebbles in a talcose *matrix*, a very hard metamorphic rock, called anagenite. At the western extremity of the gorge are schists, containing quartz and asbestos veins. I noticed in one place the interesting passage of a variety closely resembling ordinary tremolite, through true asbestos, into silky amianthus—all in the space of a few yards. These are confirmatory evidences of the plutonic agency which has upheaved the Montagnuola senese, and produced the white marble, slightly veined with grey, seen in the valley close to the water's edge, and in the cuttings by the road side opposite Spanocchia. This marble was employed, in 1364, for the Cathedral of Florence, and has been largely used for the public buildings of Sienna. Common statuary marble is found, in small quantities, at Monte Arienti, of a very fine grain, though with distinctly crystalline structure.

Thus much for the Lower Liassic group of marbles. Of the Upper Liassic this neighbourhood affords abundance. Ascending the eminence on the right, we arrive in front of the ruined castle of Monte Arienti, and enter the quarries of the celebrated *Giallo di Siena*, a splendid marble of a rich Indian-yellow colour, sometimes brecciated, the fragments being cemented together by a dark purple substance, so as so form an agreeable variety of veins. The yellow predominates when the fragments are large, but the interlacing purple veins often almost entirely replace it, and constitute the *Broccatello di Siena*. Less abundant than these is a breccia, which if I am not mistaken is no longer worked; a white or pale grey ground, clouded over with dendritic impressions of a circular form, not one-sixteenth of an inch in diameter, clearly defined, and perfectly distinct from each other, due to the presence of a minute quantity of oxide of manganese. It appears to be Upper Liassic. The mode in which the quarries are worked deserves all reprobation; no inclined planes or even a decent track has been made for the conveyance of the blocks down the hill; as usual, much of the material is wasted.

GERFALCO.

Another limestone ridge runs north of Montieri, and passing west of Gerfalco, forms the Cornate, a sharp rocky crest, seen from Elba and other distant places, as a prominent land-mark. At its northern end are quarries of red marble, apparently less altered, not being crystalline; and in the neighbourhood are seen numerous casts of Ammonites, of Forbes' group, Arietes, and more rarely Belemnites. Such marbles are known as *Rosso di Gerfalco* and *Rosso di Montieri*. A Siennese writer, of the 15th century, quoted by Targioni, mentions their being already then employed.

Other variegated marbles are found near the Val di Cecina, at Gherardesca (*Pisa*);

such kinds as are much veined are known as *Broccatello di Gherardesca*. They were employed for the *façade* of the church of Sta. Maria della Spina, at Pisa, and for the sumptuous Royal Chapel in the church of San Lorenzo, in Florence. (Targioni Tozzetti, *Viaggi in Toscana*, tom. iv., p. 963.) The *Porta Santa* marble from near Caldana and Rava in the Grossetano—a delicate peach-coloured stone, little esteemed, and not very durable, is placed by Savi in the Upper Liassic period. Quarries were already worked here by Cosmo I. (Targioni Tozzetti, *Notizie sulla storia di Toscana*, p. 206.)

CHAPTER II.

ALABASTER.

Not less interesting than the strata of marble are those of alabaster, which abound in the neighbourhood of Volterra (*Pisa*), about 40 miles south-east of Leghorn. While statuary marble is eminently a royal stone, and as such takes its place in the most sumptuous palaces and the noblest architectural structures of the world, white alabaster, in no point inferior to it in point of purity, is employed for making copies of works of art, which can be reproduced on a small scale with the beauty of the original marble statues, but at a fraction of the expense, so as to place them within the reach of the pockets of the people.

Pure white alabaster is, I believe, peculiar to the west of Tuscany, where it occurs in the Val di Marmolajo, near Castellina maritima, 25 miles from Volterra, and 18 from Leghorn. It is found in smooth ovoidal masses, sometimes attaining 3 or 4 feet in diameter.

The general section of the strata is:—

	Feet.
Light-blue bituminous marl	6
Greyish marls with selenite	6
Bituminous marls	6
Marls and clays containing masses of alabaster, irregularly disseminated .	5 to 10
Marls and clays, and gypsum beds with bituminous odour. Beds like No. 1.	6 to 10
Alternations of strata like the above; three of them containing alabaster.	

None but the white is extracted in the Val di Marmolajo.

Statuary alabaster does not lie in direct contact with the surrounding strata, but is enclosed in an envelope of greyish-yellow selenitic marl, at least an inch thick, firmly adhering to the surface; it is worked by wide shafts, or by pits, entrance being effected laterally. The distance between the masses of alabaster is frequently many yards; they are found irregularly disseminated in four or five rows. In the numerous interstices or fissures between the marly strata, often an inch or two wide, are found splendid limpid crystals of selenite frequently attaining nine inches in length.

Pure alabaster is confined to the Miocene rocks; but the coloured varieties extend into the Pliocene beds, and are even being produced at the present day. The heat to which the alabaster beds have been subjected was very inferior to that of the *soffioni*, whence boracic acid emanates, as I have elsewhere pointed out,* and where anhydrite is occasionally produced.

The coloured varieties of alabaster are found in many places in the neighbourhood of Volterra, and are known in commerce by various special names,—such as *bardiglio*, agate, &c.

VARIETY.	LOCALITIES.
Statuary	Val di Marmolajo.
White	Pomarance, Allacio and Ariano.
Veined white	Pomarance.
Spotted white.....	Pomarance.
Agate	Gesseri, Annunziata and Ugliano, near Volterra.
	Fonte bagni, near Pomarance (*Pisa*) .....
Yellow agate	Casaglia, S. Lorenzo.
Yellow	Casaglia, S. Lorenzo, Allacio.
White and yellow.	Al Pozzo, near Pomarance.
Bardiglio.....	Torricella, Ariano, and Menamuta, near Volterra, S. Lorenzo.
Yellow *bardiglio*...	Terenzana.

The price of white albaster from Allacio and Ariano at Volterra is ..... 24s. per ton
Bardiglio alabaster from Ariano... 19 ,,
Yellow alabaster from Allacio ... 60 ,,

The price of labour for the quarrymen is 1·40 fr. per diem.

The market for alabaster is at Volterra, a town where the entire population may be said to be directly or indirectly connected with the alabaster trade. There is a large number of workshops for the wholesale manufacture of statuettes from plaster of Paris models, as also for turning vases, &c.

Alabaster cuts very easily with any e

* See Chapter IV. on Boracic Acid.

tool, so that it may be sculptured with great economy; the last touches are made with a rasp. Very frequently the statuary alabaster becomes saturated with moisture; in such cases, previous to finishing the work it is placed in a carefully regulated hot-air bath where the stone soon regains its translucency.

The use of white alabaster for ornamental work dates from the remotest times of Etruscan art. Volterra was then a considerable fortress, and it was a custom to bury the citizens in caverns on the hill side, placing the bones or ashes in alabaster sarcophagi, or cinerary urns, formed of a single piece of stone, the sides being frequently sculptured with bas-reliefs representing poetical and mythological subjects, and the cover having an allegorical reclining figure of the defunct. The Etruscan Museum at Volterra contains a very rich collection of such works of art in excellent preservation, as they have been always protected from atmospheric influences.

The coloured alabaster is frequently very transparent, and takes a better polish than even the white variety, but its uses are restricted to the manufacture of vases, ornamental works, mosaics, &c.; it is much harder than the white kind.

Sig. Amerigo Viti has lately found out a process of colouring alabaster artificially, of any tint whatever, at the same time slightly indurating the stone. This very ingenious invention renders it possible to imitate with great economy the well-known Florentine mosaics, which are made of siliceous stones. Some table-tops already manufactured by Sig. Viti in this style reflect great credit on on him.

CHAPTER III.

SERPENTINE AND ALLIED ERUPTIVE ROCKS.

Most of the metamorphoses of the Italian rocks appear to be of comparatively recent origin; nor can I find any proof of their existence previous to the close of the Mesozoic period or the beginning of the Eocene. Serpentinous rocks then first upheaved the littoral of Piedmont and Tuscany, where they formed the eastern barrier of the Maremme —probably producing an archipelago of little islands, many of them rising to the height of several hundred feet, and covered by a peculiar flora in certain portions where soil was formed by the disintegration of the magnesian rocks.

Four consecutive and allied eruptions are distinguished by Italian geologists. One is considered as having occurred during the Mesozoic epoch; the others during the Tertiary period.

The geography of the serpentine eruptions has been described by Savi, who enumerates four series of them in Tuscany, lying more or less parallel to the chain of the Apennines. Throughout the whole of Italy, the lithological appearance of each successive eruption is so typical that it may be easily borne in mind, since the elements of which they are composed have a widely different chemical constitution—probably due to the then molten matter having been ejected from different depths, perhaps even from different foci.

Diallagic Serpentine. — Never enclosing fragments of Tertiary rocks; piercing the Upper Cretaceous beds; prevailing colour deep olive or leek-green, with metallic-looking grey or blackish crystals of bronzite, *generally not* exceeding a quarter of an inch in length; extremely compact and difficult to cut; susceptible of a fine polish (whence its employment in architecture); never accompanied by ores.

Euphotide or *Granitone.*—Typical form a very dense rock, with large crystals of diallage and milk-white or slightly steel-grey crystals of felspar of the hardest kind. The latter are replaced in some localities wholly or in part by steatite, as at Impruneta, where the diallage is easily cleaved by the nail: this mineral is grey and very soft, and when in large crystals renders the rock unfit for building purposes, the constituent parts having such very unequal hardness.

Near Matarana (*Genoa*), the euphotide, within a few yards of the serpentine, contains crystals of diallage half an inch in length, their size diminishing to a quarter of an inch at the junction with the older rock—whence also it is proved to be the newer of the two. In receding in the contrary direction, the crystals of diallage are perfectly developed and 1½ inch long.

In contact with the diallagic serpentine the euphotide produces a metamorphism of that rock, originating the *Ranocchiaja*. This latter is only found within a few yards of the contact of the two eruptive rocks, and is, therefore, difficult to procure in considerable quantities. It is streaked over with green and yellow markings, which anastomose like capillary blood-vessels. The margin of the euphotide in contact with the serpentine is often even and polished, as if it had been subjected to friction; frequently a space of an inch may

be seen between the surfaces, evidently produced during the act of cooling.

Diorite or *Greenstone*.—Penetrating the former; like it, of Eocene origin; the diorite and serpentine acting on the Eocene *macigno*, a micaceous sandstone, have produced the *gabbro rosso*, a brick-red schistose rock, in which the ancient stratification is sometimes clearly visible, though it is oftener broken up into fragments, rendering it very difficult to obtain even small specimens without flaws. The strata are extremely contorted, and in some places have evidently been so altered by igneous action in contact with neighbouring rocks as to have at first sight the appearance of having been themselves erupted.

Serpentine without Diallage, locally termed *gabbro verde*.—This rock is at once distinguished from the older serpentine, from the invariable absence of diallage, a circumstance which causes it to be wanting in the hardness and strength of the other variety—silicate of magnesia preponderating. White steatite is frequently found in it in such large quantities as to impart to it a soapy feel. This *gabbro* is sufficiently soft to be quarried with a pickaxe, while the diallagic serpentine requires to be blasted with gunpowder. Exposed to the great vicissitudes of the Italian climate, the *gabbro* becomes very friable, the surface readily crumbles, and it weathers to a considerable depth; a kind of steatitic clay is produced by its disintegration. The colour varies in different places, though in general consisting of yellow and green, imperfectly mixed. The colouring matter is oxide of iron or manganese; in some cases, as much as 2 per cent. of oxide of chromium.

The surface of the rock has frequently a polished greasy appearance; it does not present any planes, but has followed the sinuosities of the rock against which friction has taken place. Its structure is so incoherent that a blow with a hammer shatters a mass into small fragments; but in subterranean galleries much pervaded with water it appears to acquire much tenacity. *Gabbro* seems to me to be in many places a decomposing rock.

No feature regarding this serpentine is more important than that of its being almost invariably accompanied by rich ores of copper at its junction with the metamorphosed schists or *gabbro rosso*. These two rocks, similar in name, are entirely distinct in most other respects: the *gabbro rosso* is an aqueous, the *gabbro verde* an eruptive rock. The copper from the serpentine is not associated with galena and blende as in sedimentary rocks, but is accompanied by many asbestiform minerals.

The topographical appearance of the serpentine eruptions is very characteristic: there is an entire absence of those undulating chains or eminences, melting insensibly into one another, which enable us to classify hills into groups. These rocks form dykes, but more generally constitute whole hills of conical form, rising abruptly to a considerable height, and terminating in rugged, sharp summits. The older rocks have been much upturned and elevated, and are thrown off in every direction—the serpentine, forming the nucleus of the mountains so abundant along the west coast of the Tuscan, Modenese, and Piedmontese provinces, where it generally reaches the surface somewhere near the centre, and forming what I have proposed to call a "periclinal" axis. The older rocks, nearer the focus of action, are the most disturbed.

Many minerals are peculiar to the junction of the *gabbro rosso* and the Miocene serpentine; they are chiefly zeolites. The commonest is Caporcianite, a white crystalline mineral, tinged with pink, in structure resembling analcime. These zeolites *all contain magnesia*. They are—

	Magnesia per cent.
Savite, containing	13·50
Schneiderite	11·03
Picranalcime	10·25
Picrotomsonite	6·27
Portite	4·87
Sloanite	2·67
Humboldtite	2·12
Caporcianite	1·11

Miemmite (dolomite) contains 42·5 per cent of magnesia; *gabbro*, from la Spezia, 24·4.

Calcareous spar very commonly occurs in the *gabbro* in limpid and bohedral crystals; it probably owes its origin to the metamorphosis of the limestones. I consider all these minerals to have been produced at the period of the intrusion of the Miocene serpentine, from whence they doubtless derived their magnesia. It is also interesting to find that large quantities of the limestone in the neighbourhood have been altered into dolomites—the miemmite, a delicate greenish rock of the colour of aquamarine, being a double carbonate of lime and magnesia.

Calcareous Serpentine.—The action of the serpentines on the limestones which they have traversed is very varied. Near Matarana it may be very plainly seen on a mouse-coloured limestone, where peroxide of iron had imparted a brick-red tinge to various parts of the mass. Within a yard or two of the serpentine the rock had been apparently broken into fragments, which had been cemented by delicate veins of serpentine flowing into and filling up the cracks. This beautiful metamorphic rock, called *Oficalce*, is, in fact, calcareous serpentine; it forms a rich combination of colours—deep red and dark green, with interlacing veins of pure white calcareous spar. I would offer this explanation of its origin; total decomposition of the limestone was prevented by the pressure; the carbonic acid was partially expelled; the heat decomposed the carbonate of iron which was present in minute

quantities, and completely peroxidized its protoxide of iron, which, being no longer isomorphous with the pure carbonate of lime, was rejected as the latter crystallized out in various parts.

The *Oficalce* of Levanto (*Genoa*), a town situated in a beautiful little cove 25 miles N. of Spezia, has lately been employed to a considerable extent. The quarries, which are two miles from the coast, have the advantage of being situated by the side of an excellent new road, and are worked by the Messrs. Falconi. As in most other places in Liguria, the calcareous serpentine is the result of the metamorphic action of Miocene Serpentine without diallage on thin beds of Cretaceous *alberese* limestone alternating with beds of indurated clay. Where the clays predominate they form a cement in which are imbedded numerous fragments of serpentine; the calcareous serpentine assuming a liver-red colour by the peroxidation of the iron; the preponderance of serpentine, on the other hand, gives it a green colour. Numerous veins of pure white calcareous spar are found in both kinds. Of the two varieties the red is decidedly the most durable. The transformation of the limestones and clays into calcareous serpentine has only taken place locally, as in nests, along the line of contact of the serpentine eruptions, but throughout its whole length they have undergone partial change.

Some of the finest calcareous serpentine in Italy is to be obtained in the valley below Beverone (*Massa and Carrara*), where a new quarry was opened last year by Sig. A. Falconi, of Spezia. The *Oficalce* is here produced by the intrusion of Euphotide through the *alberese* limestone. Its colours are the most vivid and varied, and as immense blocks of the soundest description may be got out, we may augur great success to Sig. Falconi in his bold undertaking of opening out quarries in this interesting new locality.

I might speak of the famous quarries of Polcevera (*Genoa*), but as they belong rather to Northern than to Central Italy, I will only mention that they produce a well known and much esteemed calcareous serpentine.

Some quarries of Miocene *oficalce* have been lately opened not far from Leghorn, near Gabbro, at Colle Salvetti (*Pisa*), where it has been formed by the intrusion of an euphotide eruption through *alberese* limestone, *macigno* sandstone and Eocene conglomerate schists (*schisti galestrini*). It presents two varieties—that from the hill of the Termine is liver-red, and contains a preponderance of clayey elements; its structure being at the same time slightly crystalline. Meneghini found that it contains 2·93 per cent. of magnesia: the reddish cement is infusible and insoluble in acids. The green variety from the Orto is softer, and loses nearly 47 per cent. of its weight treated with acids. It closely resembles in appearance the *verde antico*, which is, however, a different thing.

Numerous as are the serpentine eruptions in Italy, the number of places where it is worked are very few. The leek-green diallagic serpentine of Prato (*Florence*) was largely employed during the middle ages for the churches of Florence and other towns, where it was placed in alternate courses with white marble, and was often intended to denote the desirable fusion of the "black" and "white," or Guelph and Ghibelline parties. Fine instances of the employment of the Prato serpentine are to be seen in the cathedral of Florence and the magnificent tower of Giotto, which is a perfect mosaic of ornamental stones. Serpentine is, however, so readily acted upon by the atmosphere that it has been found necessary to restore it in these buildings by fresh stone, and it is chiefly for this reason that Sig. Carpi has re-opened the ancient quarries at Prato. For internal decoration and furniture it is a very handsome stone, but is by no means to be recommended for external architecture.

CHAPTER IV.

BORACIC ACID.

In 1742, Targioni Tozzetti, a scientific Tuscan traveller, visited the salt works of Volterra in his rambles through the Maremme, and proceeded southward through Pomarance to Monte Cerboli, in order to examine the curious phenomenon of hot vapours which abounded in the neighbourhood. He relates how he took a stroll through the valley *which stret*ches south-east from Monte Cerboli, and reached the little torrent Possera: all around him was a scene of desolation, well fitted to strike dismay on the ignorant, but eminently suited to the contemplative mind of the naturalist, to whom the most dreary plains and barren rocks yield ample subject for useful and agreeable study.

His attention, however, was soon attracted to the scene around him; he stood close to

a yawning gulf, from which issued rumbling noises and disagreeable odours; he wished to look down and peep into the mysterious chasm to learn something of its nature, but his temerity was rewarded by a surly growl from within, and his guide told him that the noise sometimes resembled a hundred bellows, as if Vulcan himself were hard at work, while flames issued forth at night after very hot days. Though he saw no fire, the vapour served as a warning to him to keep at a considerable distance; but before long he came upon more vapour vents, *soffioni*, and little *lagoni*, or ponds of muddy blue waters, boiling vehemently, the imprisoned gases producing bubbles increasing in size till sufficiently large to cause them to burst. Dense white vapour, smelling strongly of rotten eggs, rose from the *lagoni*, and ascended to a considerable height into the atmosphere. The ground on which he stood was soft and crumbled under his feet; the decomposed rocks, and some of the efflorescent minerals, were new to him, and the subject of many curious speculations. The whole of the valley was apparently studded with such lagoons, an attempt to define the number of which was futile, connected as they were in many places by cross fissures and superficial cracks. Not a tree was visible throughout the extent of the valley; the opening of a new fissure was the signal for the destruction of all neighbouring shrubs, scorched by the subterranean heat. Occasionally, he was told, the *lagoni* would be overcharged by the rain, and their contents flow into the Possera, where the heat would immediately kill all the fish for a considerable distance down its course, the density of the atmosphere in cloudy weather pressing on the columns of vapour, causing them to lie more close to the ground and spread themselves horizontally, while the grumbling sounds in the bowels of the earth redoubled in fury. Passing on towards Castelnuovo the same lagoons were abundant, but of smaller dimensions, and according to tradition they were on the increase; on the other hand old lagoons dried up, only emitting steam at intervals.

A farm house near Castelnuovo, built 200 years before, had been suddenly undermined, a *fumacchio*, or incipient lagoon, having unceremoniously made its appearance in the kitchen, rapidly assuming the dimensions of a true lagoon. The inhabitants were utterly defenceless, and bade adieu to their ancestral tenement, the stone walls of which were soon attacked by the corroding influence of the vapours, and speedily destined, as our traveller truly predicted, to crumble to pieces. Within certain limits fertile fields were subject to be laid waste, and poisonous gases escaped, which had on several occasions proved fatal: thus he relates how a swineherd in charge of forty pigs had been overtaken by the noxious gases; all the poor animals were killed but one. Another man, who was working in an alabaster pit, was suddenly overpowered by the escape of mephitic gas through the marls, and cried loudly for help to his fellow at the mouth of the shaft; while he was being hauled up he was stifled by oppression of the lungs, and fell lifeless to the bottom. Should any luckless wight approach a lagoon too closely he would stand the chance of sinking into a quagmire, or losing a leg. Sheep occasionally fell victims when rushing too carelessly along, and after remaining a short time in the water nothing but a bleached skeleton remained. Though this picture is perhaps rather overdrawn, the temperature being very considerably above the boiling point of pure water, very serious and generally fatal accidents must have resulted.

It would be untrue to say that the *soffioni* were utterly useless. The skilled peasants would cleverly manage to roast their chestnuts in sacks placed over these vapour vents; no small convenience in a district where this article is a substitute for bread; birds, game, and cattle made the *lagoni* their winter resort, in order to escape from the cold snowy ground; the latter, indeed, occasionally frequented the neighbourhood to rid themselves of gad-flies and mosquitoes. Our traveller traced the vapours principally along the course of the rivulet, where they found their way out from beneath huge masses of rock; in their vicinity a hole made with a stick would frequently originate a little pool or *lagoncello*, from whence sulphurous vapours poured forth. As to the noxious vapours, which are nothing but carbonic acid gas, he was told that the introduction of a copious supply of water into the vents destroyed their power.

The origin of these remarkable fissures, the account of which I have borrowed from Targioni Tozzetti, was first pointed out by Sir Roderick Murchison, who proved them to have the same lineal direction as the axis of the Appennines and the serpentine eruptions of Tuscany, and to be closely connected with recent earthquakes. As the fissures would be easily blocked up by detritus, &c., I consider that they did not exist before the Deluge, at which time they would have been completely choked up and destroyed. Earthquakes, however, are common in Tuscany, one having occurred within the last year. In the *Codice della Gaddiana* it is mentioned that in 1320 a fissure was produced by an earthquake, near Velieno (Vegliani?) in the Volterrano, whence water rushed out in large quantities, great heat being also evolved, and a lake was soon formed, which finally attained the depth of 80 feet. Ugolino di Monte Catini, quoted by Repetti, while speaking of the neighbourhood of Monte Cerboli, makes no mention of lagoons, although he dwells in detail on those of Castelnuovo, whence Repetti

concludes that in the middle ages, when Ugolino lived, there were no fissures or lagoons in the former place.

In 1777, Hœffer, the chemist of the Grand Duke of Tuscany, found boracic acid at Monte Rotondo and Castelnuovo, a fact confirmed two years subsequently at Monte Rotondo, by Prof. Mascagni, well-known for his researches on the lymphatic system.

Gazzeri made some attempt to utilize the boracic acid in these waters in 1808 and again in 1816; Hœffer and Mascagni proposed to make borax from them, the latter in 1812. Mascagni, however, was too much engaged in his scientific labours to carry out his idea, for which he even obtained a patent during Napoleon's rule in Italy; he therefore ceded his right to Fossi, to whom he communicated his propositions for placing cauldrons of the solution of acid in the lagoons, as in a water bath, in order to concentrate it. Fossi was the first to obtain boracic acid in any quantity from Monte Rotondo; and I find from the *Atti dei Georgofili* (tom. xvii., Firenze, 1839), that he exhibited white glass in Florence as early as 1818, prepared with borax made from the lagoons. Messrs. Gazzeri and Brouzet worked the lagoons of Monte Rotondo from 1815 to 1818, employing as their engineer Sig. Ciaschi, who made further improvements by constructing artificial lagoons round the dry *soffioni*, to utilize the hitherto waste vapours. The poor fellow was one day superintending an operation of this nature, in 1816, when he fell into a fissure: he was dragged out half dead, and only lingered for a few days, during which time he suffered the most excruciating torture from violent spasms and frightful burns. Gazzeri and Brouzet with great difficulty managed to export to France 3 tons 5½ cwt. of very impure crude boracic acid in the nine and a half months ending April 1, 1818. A small quantity of these mineral waters had been for many years employed in pharmacy, under the name of *Sale Sedativo di Hombourg*, borax being considered a calming medicine.

Thus, for 40 years, little or nothing was done, when in 1818, M. François Lardarel, a French gentleman, then staying in Tuscany, resolved on the formation of a small establishment for the collection and extraction of the boracic acid. For many years his labours were attended with small success. The sale of the acid was steady, but the profits were inconsiderable. He was thus induced to study a more economical means of evaporation, the expense of firewood used for that purpose up to 1827 having swallowed up the greater part of his proceeds, the more so as it was particularly scarce in that neighbourhood, where not a blade of grass was to be seen, and road communication for bringing it had all to be made by the proprietor of the works.

After much thought the brilliant idea struck M. Lardarel that by some method he might take advantage of the natural steam jets or *soffioni* arising so plentifully from the soil; and at the period I have mentioned he devised the means of imprisoning and turning them to account, which I shall describe. The process was a triumph for those days, when, let us remember, steam was little known as an element in manufacturing industry. From that moment the produce of the works rapidly increased, and the uses to which the boracic acid was applied became equally numerous.

At the present time there are no less than nine separate establishments belonging to Count Lardarel, all situated within a few miles of Castelnuovo (*Leghorn*), a litle town half-way between Volterra and Massa Maritima, viz.: Lustignano, Lardarello, Lago, Sasso, Monte Rotondo, Serrazzano, San Federigo, San Edoardo, and Castelnuovo. M. Durval has one establishment at the Lake of Monte Rotondo, and a new company has just been established at Travale, near Volterra. All these places are in close proximity to eruptions of *gabbro* or miocene serpentine, as at Monte Cerboli, Serrazano, Monte Rotondo, and numerous other localities, where that rock has pierced the sedimentary strata. No one can call in question the existence of deep-seated subterranean fire in this neighbourhood; though, during the present century, no flames have been seen at the surface. I cannot help thinking that these insignificant vents can only be subsidiary to the more capacious craters of the volcanoes in the South of Italy, where more ample space is provided for the escape of the gases produced by the decomposition of mineral matter. In suppport of this theory I will presently give a comparison between the two localities.

The works are so similar that it will only be necessary to describe in detail that of Lardarello, which is highly interesting. This thriving little colony is entirely the creation of Count Lardarel, and is situated on the torrent Possera, below the village of Monte Cerboli, three miles from Serrazzano, and six from Pomarance. A group of half-a-dozen or more *lagoni* are seen on the slope of the hill, about half a mile from the main road, from which they are completely hidden by rising ground. Some of these *lagoni* are those described by Targioni Tozzetti, but the vapour-vents—the *soffioni* of which he speaks—no longer exist, as they have been artificially converted into *lagoni*.

Singularly enough, boracic acid has never been found in the solid state at any depth to which search has been made, with the exception of such places in which it has sublimed; it is probably either the result of the double decomposition of water and a volatile salt of boron, according to Dumas' theory; sulphide of boron and water producing boracic acid and sulphuretted hydrogen, thus:—

$$Bo\,S^2 + 2\,HO = BoO^2 + 2\,HS.$$

or simply chloride of boron and water producing boracic and hydrochloric acids, thus:—

$$BoCl^2 + 2\,HO = BoO^2 + 2\,HCl.$$

in support of which supposition we only find the boracic acid appear when there is water present; or it may be caused by the reaction of sulphuric acid on borates, such as tourmaline, the granite found not very far off being so rich in this mineral as to bear the name of tourmaliniferous granite. The theory I advance is tenable, provided we assume the heat to be very great. Though sulphuric acid is one of the most powerful, and boracic acid the weakest, next to carbonic acid, at ordinary temperatures, they exhibit the reverse phenomena at very elevated temperatures; in fact, boracic acid under such circumstances will actually decompose sulphates formed by the action of sulphuric acid on borates. Before water is introduced into the fissures they are mere *soffioni;* borates of several bases are most probably abundant at great depth, and are uninjured by the constant passage of sulphurous vapours, and even sulphuric acid, on their way to the surface, whence the latter escape, but boracic acid is not to be detected. Water being now introduced lowers the temperature, and the balance of affinities is altered, the powerfully corroding influence of the sulphuric acid on the borates is set in operation, whence the boracic acid is liberated, and ascends in solution with the ejected water and steam.

The following is the analysis of the dry gases issuing from a *soffione* examined by Payen:—

Carbonic acid	57.30
Nitrogen	34.81
Oxygen	6.57
Sulphuretted hydrogen ...	1.32
	100.00

Respecting the temperature of the fissures, none have satisfactorily treated the question, though it has excited much attention from Pilla, Murchison, Lardarel, &c. I think that some light is thrown on the subject by the presence of an instructive mineral round the lagoons, viz., Anhydrite (Ca O. SO^3), evidently formed at a temperature at which water could not combine with the sulphate of lime to produce ordinary gypsum. When gypsum (CaO. SO^3 + 2 HO) is heated to 260° Fah., it loses its water of crystallization, and becomes plaster of Paris; but on cooling it again absorbs the original quantity of water. When it is heated to redness this does not take place, but the mass melts into an enamel, which, according to Regnault, is identical with anhydrite. The heat, on the other hand, could not be very much above redness, provided my theory of the borates be correct.

The first care of the manufacturer is the removal of a certain quantity of clay, and the formation of a *lagone* or basin, of more or less circular form, the sides of which have to be strengthened by rough stones to prevent them from falling in, the tenacity of the clay sufficing for the bottom. The usual depth of a *lagone* is from 4 to 6 feet, more rarely as many yards; the capacity and depth have to be regulated with the utmost care, according to the force of the vapour in that particular vent. During the period that the workmen are employed in digging a *lagone*, the steam is conveyed away into the atmosphere, far above their heads, by means of a tall wooden chimney, which protects them from being scalded. A stream of water has been brought to the uppermost lagoon at Lardarello, from near the Bagno del Morbo, not a quarter of a mile off; this lagoon is about 15 or 20 yards in diameter, with a jet of steam in the centre. Forcing its way through the fissures by its specific gravity, the water comes in contact with the highly-heated gases and rocks, and is immediately converted into steam, which, from its elasticity and enormous increase in volume, is ejected with great force, but is condensed as soon as it reaches the surface of the basin by the colder water around. This incessant vaporization of the water and its subsequent liquefaction produce a great commotion in the lagoon, a turbulent little fountain rising to the height of a foot, and causing a succession of concentric ripples. All this time there is a copious discharge of sulphuretted hydrogen, which in one case I distinctly perceived at night-time full a quarter of a mile from a lagoon, and before I knew of its existence there.

Having remained 24 hours subject to continual agitation, the water, which has become of a slate-blue colour, is let out of the lagoon, and passes into a canal, through which it is conducted into a second basin at a lower level; thence it passes through several more, each lower than the last, though of similar construction. In this manner the water dissolves the boracic acid in the fissures, and brings it up mechanically mixed with it. No other object appears to be attained by making all the water pass through the chain of *lagoni* than to obtain boracic acid of uniform density, though Dumas expressed to Count Lardarel the opinion that probably, by some ingenious device, it might be brought to a saturation of 15 to 16 per cent.—a great desideratum. The temperature of the liquid is considerably above 212° Fahr., and dense vapours rise for many yards above the ground, heating the air so much as to render it unpleasant to remain long near them. Efflorescent minerals and decomposed rock, ejected with the steam, lie scattered all round on the heated surface of the ground, along with sulphur incrustations and many sulphates, such as gypsum, alum, and sulphate of ammonia, besides iron

pyrites in minute veins in the fragments of rocks.

The water passes at stated intervals, while still boiling, into the *Vasco*, a tank, sixty feet square, which is covered by a tiled roof supported at the sides by slight brick pillars. Here the greater part of the mechanical impurities, clay, and the more insoluble sulphates, sink to the bottom, and the water regains its limpidity. The next operation is to concentrate the solution of acid, which is effected in the adjoining building containing the evaporating pans: these are so exceedingly ingenious and simple as to merit particular consideration; Count Lardarel, who invented them, has given them the name of Adrian evaporators. Three parallel series of shallow leaden divisions, called *Scanelli*, are placed in a line, each being a third of an inch below the one before it, from which it is only separated by a leaden partition half an inch broad, and as deep. The *scanelli* are placed transversely, and are 6 feet long by 22 inches wide; they are arranged under a roof, to keep off the rain, but the evaporation is not in any degree impeded, since the sides are open, and only a few brick pillars of the lightest construction are employed to support the roof. The length of the building is often several hundred feet. At the commencement of the operation a man turns a tap, which lets the water flow in regulated quantities, from the *vasco* into the first *scanello*, everything depending on this precaution; it now flows on from one division of these diaphragm pans to another, until, arriving at the bottom of the building, it passes along the second row of divisions, and finally back through the last series into the diagonal corner, where there is a large and deep reservoir called the *Caldaja a sale*. In its progress the water gradually evaporates: as I mentioned before, it only contained 1½ or 2 per cent. of boracic acid when it entered the building, but after having passed through fifty or sixty divisions, it assumes a decidedly yellow tinge, increasing in intensity until finally it becomes a bright golden yellow fluid, having a characteristic odour. The internal arrangements of the evaporators, though they may appear simple enough, were the result of much thought. The leaden pans are supported by beams over a low vaulted steam-passage, lined with hydraulic cement, to protect the stone-work and keep in the heat. For this purpose, a *soffione* is vaulted over with a stone dome, about ten feet high, firmly bound with wrought-iron bars; water is admitted, and the imprisoned high-pressure steam thereby produced acquires immense power, and thumping loudly against the dome, the jets of water seem ready at every moment to undermine the structure. The steam now passes through the vaulted passage into the lower chamber *of the evaporators*, and, having traversed it from end to end, finds its way out into the open air through a chimney at the opposite end. What formerly took 62 hours to evaporate, is performed by this beautiful contrivance in 12, the expense being also proportionably diminished.

From the *caldaja a sale* the syrupy liquor is periodically conducted along a wooden pipe to the *Bollajo*, or crystallizing house, in which a series of large barrels, *tonne*, 3 or 3½ feet in diameter, are arranged in a line. When it is desired to fill them, all that is necessary to be done is to remove a plug placed over the centre of each barrel in the pipe which runs round the building: the liquor remains four days in the barrels, during which time it has crystallized at the sides and bottom to the thickness of several inches, the liquid portion is then withdrawn by removing a plug, and finds its way along a longtitudinal drain, by which means it is all saved for future use. No one could fail to admire these beautiful processes, whose characteristic merit is that they do not necessitate anything being lost.

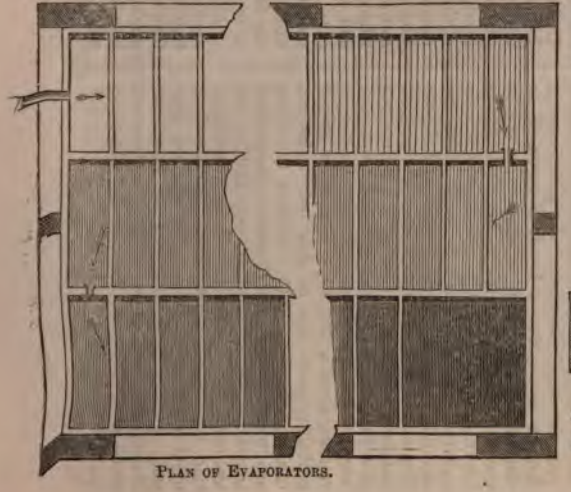
The boracic acid crystallizes in hexagonal plates, about the size and thickness of a wafer, having a flaky appearance and pearly lustre. From their peculiar form they naturally retain much water mechanically mixed, so that they are first put in large wicker baskets, *Corbelli*, to drain, and then emptied out on the floor of a large airy chamber, called the *Asciugatojo*, or drying house. The brick floor is heated, like the evaporators, by steam passing through an underground chamber. The boracic acid being spread out in thin layers on the floor, is stirred from time to time with a wooden rake, and the crystals, while losing their sharp angles, separate in great measure from each other. When dry, nothing remains to be done but to shovel up the mass of crystals and remove them to the warehouse, where the produce of all the establishments is mixed, to ensure its being all of uniform quality. It is then put in large barrels, containing 2,000 Tuscan lbs., or 13½ cwt., and conveyed to Leghorn, whence the greater portion is exported to England.

The table (See page 34), very kindly given me by Count Lardarel, to whom I may be permitted to return my best thanks, shows the production of the works commenced in 1818 by his late father. The weights are reduced into English tons.

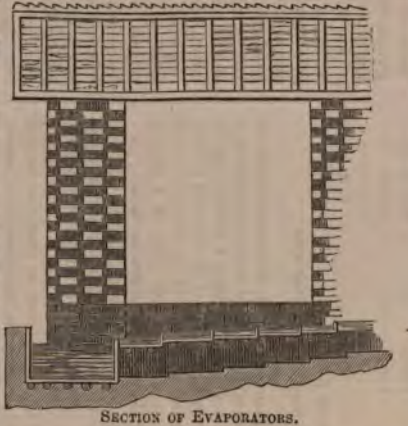
The first impression produced on my mind, after having gone through the whole establishment, was the marvellous *simplicity* of the successive processes, almost everything being performed by Nature: little has to be effected by human agency but to convey water to the *lagoni* and regulate the supply in the various operations, to empty the barrels, and spread out the crystals on the floor to dry. Such is the work allotted to the 40 men who are employed at Lardarello on ordinary occasions.

DETAILS OF BORACIC ACID MANUFACTURE.

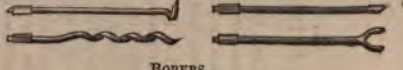
STEAM CHAMBER. STEAM PIPE. ADRIAN EVAPORATORS. RESERVOIR.



PLAN OF EVAPORATORS.



SECTION OF EVAPORATORS.



BORERS.

CRYSTALLIZING HOUSE.

SUPPLY PIPE. DRAIN. CRYSTALLIZING VATS.

DRYING CHAMBER.

	Tons.	cwt.
From 1818 to 1828 (ten years) ...	521	16
„ 1829 „ 1838 (ten years) ...	4,870	6
1839	748	13
1840	878	13
1841	886	6
1842	923	15
1843	923	16
1844	923	16
1845	923	15
1846	1,043	13
1847	1,043	13
1848	1,043	13
1849	1,043	13
1850	1,043	13
1851	1,140	0
1852	1,156	19
1853	1,208	19
1854	1,319	7
1855	1,332	19
1856	1,427	1
1857	1,711	4
1858	2,026	10
1859	1,830	18
Total ...	...29,972	18
Or, Tuscan pounds ...	...86,155,917	

In 1861, more than 1,800 tons.

They commence at 4 a.m. in summer, and at sun-rise in winter, and only work on an average *four or five hours* daily: thus I arrived at 10 a.m., but they had finished for the day! The art of procuring boracic acid is, however, very harrassing; sometimes the side of a lagoon break in, or there is not sufficient water; perhaps through carelessness on the part of the men the steam supply diminishes at a particular spot, as is liable to occur, unless they regulate the quantity of water accordingly; the inevitable consequence is that the lagoon becomes useless, and the steam seeks an easier vent for itself elsewhere. In some cases it forms a new *soffione* a hundred yards off, or else, unable to force an immediate passage to the surface, it is needful to have recourse to boring, and a perfectly new lagoon is constructed. This operation is by no means an enviable task; the ground feels so hot near fissures which do not quite reach the surface, but from which steam issues out in minute jets, that I had my feet scorched through a very thick pair of shoes, and one is warned to retreat, since a few steps further on would probably cause one to sink into a hidden cauldron, or steam-bath. Around this place are fragments of *alberese* limestone, the gradual metamorphoses of which are very visible; first the rock, which has a dirty-brown discoloration, is shivered and rendered friable, and in other places absolutely converted into gypsum, as has been described by Savi and Meneghini; besides these there are clays and marls of the Eocene, Miocene, and Pleiocene *formations.*

I should not consider my description of the lagoons complete without being permitted to turn the attention of the reader to the character of Count Lardarel, the originator of the works, who only died in 1858. Endowed with great enthusiasm, combined with indomitable perseverance, he carried out many grand ideas; his mind seems ever to have been bent on some useful project. He became the master of a truly colossal fortune by his well-merited and praiseworthy exertions; nor did he selfishly keep his gains to himself, but laid them out usefully, and, by giving employment to a great number of the working-classes in Leghorn and other towns, as well as on his establishments, he rendered great public service. We have to thank him for the extensive use the boracic acid glaze has been able to acquire in the manufactories of Lancashire; and Italy, his adopted country, will ever be grateful for the oasis which he has planted in the midst of the most sterile lands of the Maremme. A picture of the *Piazza dell'Industria*, at Lardarello, will convey some idea of the man.

On one side is a handsome block of buildings, including the necessary offices, a laboratory, museum of mineralogy, apothecary's shop, philharmonic society, boys' and girls' schools, and weaving looms for the wives and daughters of the workmen. In the centre of this terrace is a very handsome church, the priest also performing the office of schoolmaster. Opposite is a neat and spacious hospital, to which are attached a physician and surgeon, as is the case in all the other establishments. On another side is the house where the count lodges when he comes to inspect the works, and a neat little theatre, where the men amuse themselves by getting up plays. In the centre of two large squares are the marble statues of the late Grand Duke Leopold I. and an allegorical figure of Industry. I might mention the establishment of road communication, by means of a bridge which cost £20,000, over ground very unfavourable for its erection; the space under one of the archways having been made into a paper manufactory. I must not forget the shops where the men may purchase necessary commodities, nor the model lodging-houses, where they have apartments for themselves and families. Who can view these institutions, so well calculated to advance the social condition of the too ignorant working classes in Italy, without being pardoned for digressing for a moment from the more beaten track of technological description?

The count established a fund, by which the men, sacrificing a day's wages per month, are free to the enjoyment of the whole of these liberal institutions, including house-rent. As might be anticipated, the apothecary's shop is largely frequented by villagers from the neighbourhood, who obtain drugs free of ex-

pense. The late Grand Duke of Tuscany, alive to the good which M. Lardarel had done and was doing, ennobled him with the title of Count of Monte Cerboli. If I were asked to erect a monument to him at Lardarello, I would place no statue, but simply copy the beautiful epitaph applied to Sir Christopher Wren, in St. Paul's Cathedral, London, "*Si monumentum quæris, circumspice.*"

The lake of Monte Rotondo, belonging to M. Durval, contains $\frac{1}{500}$ of boracic acid in solution, the maximum of impurities being 15 per cent., chiefly sulphates of lime, ammonia, alumina, and magnesia, hydrochloric acid, and free sulphuric acid, with traces of organic matter. The area of the lake is about 18 acres. M. Durval produced from it 64 tons in 1854 and 142 tons in 1855.

Within the last year Prof. De Luca has analyzed two specimens of boracic acid from M. Durval's works; these he has kindly communicated to me, and not having been published before, they are additionally valuable, and are as follows:—

	No. 1.	No. 2.
Anhydrous boracic acid	50·7	46·6
Water	36·9	40·4
Sulphuric acid	9·1	9·5
Chlorine	0·2	0·1
Silica	1·0	1·2
Magnesia	1·1	1·3
Lime	0·5	0·6
Ammonia	0·3	0·4
Potash, soda, alumina, oxide of iron, and organic matter	traces.	traces.
Total	99·8	100·1
Impurities in the above	12·2	13·1
100 parts give of crystallized boracic acid	89·0	84·3

Travale.—Within the last two or three years a new company, called the *Società Anonima di Travale*, has commenced operations near Montieri (*Pisa*), for extracting the boracic acid which is there found in small quantities, associated with a large proportion of sulphate of ammonia. The locality is north of the fracture we have been describing, but it remains to be proved whether it offers such a brilliant future as the other lagoons.

The remarkable analogy between the lagoons and volcanic craters will be best seen by a comparison of the products found in their respective places.

The following is a list of some of the gases and minerals from the Tuscan boracic acid lagoons, compared with those from Vulcano, in the Lipari Islands, &c., which will show their intimate connection with volcanic action:—

1. Sulphuretted hydrogen is found in large quantities, as at Vulcano. Pilla remarks that Vesuvius emits hydrochloric acid in great abundance, as do Etna and all other active volcanoes, while quiescent ones pour forth chiefly sulphuretted hydrogen, which is disengaged at lower temperatures than is necessary to liberate the former. (*Trattato di Geologia*, tom. i., p. 244).

2. Sassoline, Boracic acid, BO^3. 3 HO; also in Vulcano:—

Boracic acid	56·4
Water	43·6
	100·0

3. Hayesine, Borate of lime, CaO. 2 BO^3 + 3 HO; also at Iquique, Peru:—

Lime	20·85
Boracic acid	51·13
Water	26·25
Silica, Alumina, and Magnesia	1·75
	99·98

4. Lagonite, Borate of iron, Fe^2 O^3. 3 BO^3 + 3 HO; as incrustations:—

Sesquioxide of iron	36·26
Water	14·02
Boracic acid	47·95
Magnesia and loss	1·77
	100·00

5. Lardarellite, Borate of ammonia, NH^4O. 4 BO^3 + 4 HO:—

Ammonia	12·73
Water	18·32
Boracic acid	68·56
	99·61

6. Borax? NaO. $2BO^3$ + 6 HO:—

Soda	19·25
Water	37·19
Boracic acid	43·56
	100·00

(Ordinary borax contains 10 atoms of water.)

7. Mascagnine, NH^4O. SO^3 + 2 HO; also in the Lipari Islands:—

Ammonia	34·67
Sulphuric acid	52·33
Water	12·00
	99·00

8. Gypsum, CaO. SO^3 + 2 HO (Impure).
9. Selenite, CaO. SO^3 + 2 HO.
10. Anhydrite, CaO. SO^3:—

Lime	41·2
Sulphuric acid	58·8
	100·0

11. Alum (probably ammonia and iron alums).
12. Sulphate of magnesia (rare), $MgO.SO^3$.
13. Sulphate of ammonia.
14. Iron pyrites, $Fe\,S^2$.
15. Sulphur incrustations, S;—also in the Lipari Islands.
16. Resinous quartz, SiO^2.
17. Common salt:—Na Cl.

The connection between the *soffioni* and volcanic craters has been proved in a remarkable manner by the discovery of boracic acid crystals in the minor crevasses produced near Torre del Greco during the eruption of Vesuvius in the winter of 1861.

The boracic acid crystals are far from pure, containing a small quantity of numerous sulphates, mechanically mixed. In 1842, Wittstein (*Rapp. ann. de Berzelius*), published the following analysis:—

Crystallised boracic acid (3 H0. $B0^3$).		76·494
Sulphate of	Iron	0·365
	Alumina	0·320
	Lime	1·018
	Magnesia	2·632
	Ammonia	8·508
	Soda	0·917
	Potash...	0·369
Chloride of Ammonium		0·298
Water of crystallization of the above salts...		6·557
Silicic acid...		1·200
Sulphuric acid combined with boracic acid		1·322
Organic matter and sulphate of iron...		traces.
		100·000

The amount of foreign salts has very considerably diminished since the *lagoni* were first made use of; I believe it is not more than 13 per cent. at this time. In order to purify the crude produce, which is not done in Tuscany, nothing further is necessary but to re crystallize it once or twice.

It will suffice to mention that the uses of boracic acid are only limited by the supply. The greater part of what Count Lardarel produces is exported to England, that of M. Durval supplying the necessities of the French market.

The Custom-house returns show that the importation of boracic acid (see next column), produced by Count Lardarel and M. Durval, from Tuscany into England, has been as follows; the quantity of olive oil is given for the sake of comparison, as being better known to the public.

Thus the sixth part of the imports from Tuscany into England, *representing* £100,000 *per annum, is derived from the evaporation of mineral waters*, an item second only in value to the celebrated oils of Lucca and other parts of the country.

Mr. Wood, of Liverpool, applied boracic *acid to glazing* pottery in 1820, and for that branch of industry an enormous quantity is consumed.

Years.	Boracic Acid. Quantities.		Boracic Acid. Value.	Value of Olive oil imported from Tuscany during the same period.	Total imports from Tuscany.
	tons.	cwt.	£	£	£
1852	935	1	...	...	...
1853	1,038	8	...	...	...
1854	1,185	9	106,691	68,853	751,595
1855	1,338	16	121,163	142,893	747,967
1856	1,253	0	110,264	130,711	554,437
1857	1,245	12	87,192	103,914	534,494
1858	1,156	15	73,157	123,892	538,500
1859	1,785	17	94,846	117,398	648,460
Totals			£593,313	£687,661	£3,377,453

The glaze for common English porcelain differs only from that employed for figures and ornaments in the amount of borax and silica. Their respective composition is:—

Felspar	45 ...	45
Silica	9 ...	12
Borax	21 ...	15
Flint Glass	20 ...	20
Nickel	4 ..	4
Minium	12 ...	12

—(Dumas, *Traité de Chimie*, tom. ii., p. 265.)

With silicates of the alkalies and various metallic oxides, it forms that beautiful and brilliant greenish-yellowish glass, made at Sèvres, of which the composition is given below:—

Silica	19·23
Protoxide of lead...	57·64
Soda	3·08
Boracic acid	7·00
Peroxide of iron	6·12
Oxide of zinc	2·99
Antimonic acid	3·41
Potash	0·44
	100·000

—(Salvetat, *Annales de Chimie et de Physique*, 3ième Série, tom. xv., p. 122.)

M. Maës, of Cliny la Garenne, near Paris, manufactures glass of boro-silicates of potash and zinc, boro-silicates of soda and zinc, and boro-silicates of potash and baryta.

I was informed by several persons that the vines in the neighbourhood of the lagoons do not get the Oidium disease, which may possibly be attributable to the sulphurous vapours which arise so plentifully and pervade the atmosphere—perhaps even in a less degree to the sulphuretted hydrogen; hence this locality is well adapted for the growth of vines, wherever the soil in the lower valleys admits of their cultivation. May not this continual vapour of sulphurous acid be the chief reason of the excellence of the celebrated wines of Vesuvius? For a similar reason, I would ascribe the superiority of the Canary wines as much to the sulphurous bath to which they are subjected, as to the richness of the soil, though that also is incontestable.

CHAPTER V.

ROCK SALT.

The Royal salt works of Volterra (*Pisa*) are the most important in Central Italy; they are situated on the river Cecina, within three miles of the town of Volterra, and 40 from Leghorn.

Unlike the well-known salt deposits of Cheshire, Prussian Saxony, &c., which belong to the Triassic formation, the rock salt of Volterra occurs in beds varying from 15 to 40 feet thick, in ash-grey Miocene or Middle Tertiary clays. I shall several times have occasion, in the course of the present publication, to allude to the circumstance that many of the most valuable minerals in Central Italy originated in Tertiary times, a fact which I developed some years ago in a paper I presented to the Geological Society of London.

There are eight pits, of an average depth of an hundred feet, from whence the brine is pumped by horse-power, and conducted along a wooden canal to the salt works. As some of the pits furnish weaker brine than others they are only occasionally employed in dry seasons, when the brine, becoming too strong, requires a judicious admixture of water containing less salt, in order to reduce its specific gravity to 20° or 21° of Beaumé's areometer, which experience has proved to be the most convenient strength for evaporating.

The pits being supplied by water filtering naturally through the soil, the brine continually varies in strength according to the direction of the wind and the amount of rain that falls.

The method of manufacturing salt at these works has undergone considerable change and improvement during this century. The salt works at present consist of two principal large buildings, each provided with two complete evaporating apparatuses. The pans for evaporating the brine (*caldaja di Salinazione*) are made of boiler-plate, and are 28 feet 9 inches long, by 21 feet wide and a foot deep. To each pan are attached two others, of somewhat larger dimensions, for concentrating the brine. Each of the brine pans is provided with three fire-places, for burning wood; the waste heat is turned to account for the concentrating pans.

Until very recently four pans were enough to supply the demand for the whole of Tuscany, but as the price of the salt has been reduced very considerably of late years, the consumption has increased, and they are no longer adequate to the purpose.

No returns are preserved of the quantity of salt produced at these works up to 1821, but the present director, M. Brasseur, very kindly furnished me with the statistics for the last 40 years, with the annual cost price, which will form an important addition to these remarks.

PRODUCTION OF SALT AT THE ROYAL SALT WORKS OF VOLTERRA.

YEAR.	Quantity Manufactured.	PRICE.	
	Tons. cwt.	Per 1,000 kilos.	Per cwt.
1821–5, mean of 5 years	5,470 6	41·82 frs.	1s. 8¼d.
1828–32, ,, ,, ...	6,273 16	38·23	1s. 6½d.
1849	6,660 4	31·86	1s. 3¼d.
1850	6,908 5	30·32	1s. 2¾d.
1851	7,170 9	30·32	1s. 2¾d.
1852	6,837 13	31·64	1s. 3¼d.
1853	8,744 13	26·05	1s. 0¼d.
1854	7,023 6	28·81	1s. 2¼d.
1855	6,896 5	28·63	1s. 2d.
1856	7,321 11	27·06	1s. 1½d.
1857	7,221 1	26·89	1s. 1¼d.
1858	6,754 7	27·72	1s. 1¾d.
1859	7,234 10	27·84	1s. 1¾d.
1860	7,982 13	28·55	1s. 2¼d.
1861	6,777 7	——	——

Eight per cent. tare is allowed for water mechanically mixed with the salt after weighing it. The retail price of salt is 33 francs per 100 kilogrammes, or 13s. 6d. per cwt.

There are 90 workmen at the salt works of Volterra, who with their families make a total of 220 persons who live by this branch of industry.

CHAPTER V.

IRON.

Elban Iron Mines.

The whole of the Elban iron mines are the property of the Government. The late Government of Tuscany worked them on their own account up to 1851, when a loan of 12,000,000 Tuscan *lire* (£400,000) at 5 per cent. was negotiated with Messrs. Bastogi and Co., of Leghorn, for thirty years, with a certain per centage on the profits—the smelting establishments on the mainland being given as a mortgage. The mines are under the immediate superintendence of the Minister of Finances, to whom the director hands in his reports. The metallurgical department at Follonica is under M. Ponsard, who has been recently appointed, and to whose scientific skill great improvements are due. There is no engineer on the island, the affairs being managed by M. Ulrich, a gentleman residing at the Marina di Rio, who, with the title of *Administratore all' Isola*, has charge of the accounts, the superintendence of the various mines, and the shipment of the ores. The title of the Company is *Administrazione cointeressata delle R. R. miniere e fonderie di ferro dell' Elba;* there are 24,000 shares, each originally of 1,000 Tuscan *lire* (£33 6s. 8d).

The largest mine is that of Rio, the only one permanently worked up to 1851: since that period a very considerable excavation has been made at Capo Calamita; other smaller mines have been in activity for several years at Terra Nera and Rio Albano; one at a spot called the Vigneria, though distant half a mile from Rio, may be geologically considered as part of it; the former is worked from the seashore, the latter is considerably higher up the hill. Such are the localities hitherto in operation; they each present peculiar features of interest, which render it convenient to consider them apart, after taking a more general view of the subject.

All the iron ore extracted in Elba is remarkable for its purity and richness; fifty-two per cent. is there considered poor, the average being sixty-five per cent. It is absolutely free from the impurities so commonly found in British iron ores, especially in clay-iron stones, such as phosphorus, sulphur, &c., small portions of which are extremely detrimental to the quality of the metal they produce. While the quality of the Elban ores is second to none in the world, the quantity is so prodigious that, notwithstanding I had heard so much about it before my visit, and had consequently formed high expectations, they proved to be anything but overrated. Elba is truly an island "whose stones are iron, and out of whose hills thou mayest dig brass." In order to proceed as systematically as possible, I will take a topographical *reconnaissance* of the island of Elba, especially the eastern portion, to which the iron mines are entirely confined.

Let us suppose the island to be submerged 50 feet, we should then find it to present a totally different outline. The western portion, constituting Monte Capanne, would appear as a lofty and rugged granitic mountain, either forming an island, or united by a narrow isthmus to a second group of hills, entirely differing from it in origin and appearance. In fact, the former is a precipitous igneous mass, with an iron-bound coast; the latter a series of gently undulating limestone and schistose hills, pierced in various directions by dykes and intrusions of serpentine and allied eruptive rocks. To the north of this we should find several small islets, formed of porphyritic rocks, altered granites, pegmatite, schist, and serpentine; one of these would correspond to the hill on which stands the fort of Portoferrajo, and several others to those on which are established coast-guard stations. The harbour of Portoferrajo would no longer exist, and the site of the town be for the most part under water; while a narrow arm of the sea would pass from Portoferrajo on the north to the Golfo di Longone on the east, and the Golfo della Stella on the south, cutting off to the east two large islands, of which I am about more particularly to treat, as containing such abundance of iron ore.

Commencing at Monte la Sera, a chain of lofty hills runs southward for several miles to Monte Serato, flanked on the east by lesser hills; upon one of these is built the chapel of Sta. Catterina, the rock being serpentine in contact with limestone. A mile beyond is the conical peak on whose summit stand the dismantled ruins of the Torre di Giove. If we ascend to the top of Monte Giove, we shall see the relative positions of the mines of Rio and Rio Albano; the former about a mile to the south, the latter at an equal distance in a north-easterly direction; the little excavation of Vigneria lies rather nearer to the south-east, but though hidden, its position may be easily guessed by the little boats which lie off the beach. Carrying the eye southward, the view is shut out by two lofty hills, Monte Fico, and the limestone ridge of Monte Arco.

Behind this latter eminence, 4½ miles in a direct line from where we are supposed to be standing, is the mine of Terra Nera, situated on the slope immediately overlooking the Gulf of Longone. These mines have been formed in places where the quantity of the iron was supposed to be the greatest and easiest of access, but numerous veins traverse the rock in the intermediate spots; some consist of excellent peroxide of iron, others silicates of less industrial importance. The general direction, drawing a line through these various points, will be a little east of north to west of south. Following precisely the same course southward across the Gulf of Longone, is another interesting group of iron workings at Capo Calamita and Monte Calamita (the loadstone cape and mountain), so called because the mass of the ore is magnetic iron, the slope of the hill down to the sea level being almost entirely covered with a deep deposit of the best mineral, with little intermixture of inferior ores.

The first authentic mention of the Elban iron mines is by Hecatæus, a few years after the death of Tarquinius Superbus, last king of Rome, and therefore verging on 2,400 years, a period which, if doubled, would carry us back to the youth of Methuselah.

The Greeks were early acquainted with Elba, under the name of Æthalia, *Αἰθάλην; αἰθάλη* signifies *soot*, and Cerda says that the name was derived from the furnaces employed for smelting iron, a metal in which it was very rich. We may possibly attribute the origin of the iron mines to the successors of the Argonauts; Portoferrajo was called by the Greeks *Λιμὴν Αργους*, or Portus Argous, from *Argo*, the vessel which conveyed Jason and his 54 Thessalian heroes, whom Strabo distinctly believed to have landed in Elba. We may infer that the Etruscans very early worked iron in Elba, since I heard, during my stay at Portferrajo, that Etruscan iron coins had been discovered in the island.

"Ilva was celebrated in ancient times, as it is at the present day, for its iron mines; these were probably worked from a very early period by the Tyrrhenians of the opposite coast, and were already noticed by Hecatæus (circum. 520 B.C.), who called the island *Αἰθάλη*, indeed its Greek name was generally regarded as derived from the smoke of the numerous furnaces employed in the smelting of iron." (Diodorus Siculus; v. 13.)

Virgil, alluding to the troops which accompanied Æneas from the Tuscan coasts, sings of Ilva, the noble island, blessed with inexhaustible quantities of ores of steel (ores from which steel was then manufactured). His account is just such as I should myself give:

"Sexcentos illi dederat Populonia mater
Expertos belli juvenes; ast, Ilva trecentos
Insula inexhaustis chalybum generosa metallis."
(*Æneid*, lib. x., 172.)

Varro (born B.C. 116) says that iron ore was, indeed, abundant in Elba, but in order to be smelted it had to be taken to Populonium, a city of Etruria, not far distant from the island.

About the Christian era, Strabo alludes to the iron mines of Elba as nothing new, and specially mentions that the ores were taken to Populonia to be smelted, since the island did not afford facilities for the requisite metallurgical operations. What the difficulties were he does not inform us, though I conceive the want of forests, which had been previously cut down, quite a sufficient reason. "Optime a Populonio solvunt tres illas insulas (Æthaliam, Cerniam, Sardiniam) petituri, quas et nos vidimus Populonio conscenso et metalla quædam ibi locorum deserta: vidimus etiam qui ferrum ex Æthaliâ allatum elaborarent. Non enim eâ in insulâ fornacibus liquari potest; sed statim atque effossum est in continentem perfertur." (*Geographiæ*, lib. v., cap. ii., § 7.) Populonium is the best starting point for those who set sail for Elba, Corsica, and Sardinia. These islands were visible on ascending the heights above Populonium,* and also certain abandoned mines; we likewise fell in with some of the men who work the iron ore brought from Æthalia, as they cannot smelt it in furnaces in the island itself, so that, when extracted, it is at once shipped to the continent. This explains the passage in Aristotle (born B.C. 384), which alludes to *Populonio ferro; i.e.*, Elban iron, smelted even in his time at Populonia.

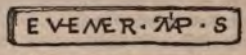
The intercourse of the Romans with Elba may be inferred from their coins dug up there from time to time: I believe they chiefly belong to the reign of Constantine, more rarely to Augustus, Trajan, and Nero. In every part of the island ancient slags may be observed, considered to have been produced in the metallurgical operations of the Romans. Little furnaces were evidently established at some remote time wherever abundance of wood and a small stream of water were procurable within easy access of the beach. Such slags I picked up in considerable quantities in a wood at S. Giovanni, near Portoferrajo; the fragments are about two or three inches across, and may be found by slightly scratching the surface of the ground; and in draining a field at S. Giovanni just before my visit, many fragments of specular iron were turned up, so that for a short time I was puzzled to account for the way in which they came there. Similar little pieces of ancient slag are seen at the Golfo dell'Ancona, the Golfo della Biodola, east of the Punto del Pinello, on Monte Orello, at Fabrello, Capo Castello, Magazzini,

* With due deference to the authority of Strabo, he is mistaken in asserting that he saw *Sardinia*; the islands visible from Populonia are Elba, Corsica, Capraja, with others of less importance.

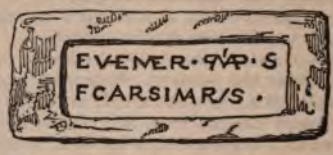
Treacque, Acquaviva, Procchio, Bagno di Marciana, Capo S. Andrea, Patresi, and at Casaccia, near Portoferrajo.

No locality offers more historical and archæological interest than Capo Castello, where I perceived a deep bed of slag exposed in section by a small winter torrent, just as it reaches the beach. Strong walls are still plainly visible here in several places; the irregular stones of which they are composed being so strongly cemented together that, rather than separate them from the mortar at the original joints, it is easier to break off large masses. A beautiful inlaid pavement is partially laid bare, consisting of lozenge-shaped pieces of Elban *Cipolino* marble and other varieties; bricks and tiles are also procurable by dint of careful search. One apartment which I entered, about 10 feet by 15, might have probably served as a bath-room. In the brushwood behind many bricks and flat tiles with inscriptions have been excavated. Part of the wall is built of small bricks laid diagonally in patterns, surrounded by rubble work, and supported at intervals by pillars of hewn stone. The plinth is also formed of the same material. Captain Pisani, an indefatigable investigator, has dug up many tiles at this place with perfectly legible inscriptions. Some of these I have transcribed.

Adjoining this is a field, in which was discovered, some years ago, a long leaden water-pipe, intended for the supply of the fort at the extremity of the cape, whence it derives its name of Capo Castello. Tracing back the leaden conduit, two bronze vessels and a tap were found, only slightly rusty; ancient foundations were also discovered, and have been since built on, the superstructure now serving as a country-seat. I here met a countryman who assured me that his father had, many years ago, discovered a large vase at this spot, which, on being broken open, was found to be full of antiquities; these he sold on his return home for two pairs of trousers, with, perhaps, a little *buona mano;* the purchaser became suddenly rich and possessed of 40,000 francs (£1,600). The church of Sta. Catterina, below Rio, was built with the profits. Nenci, the perhaps too credulous historian of this island, says that in this ancient building a certain Queen Ilva held her court, after she had fled with her lover from the Etruscan mainland pursued by her father and brother. Rather than return, Ilva is fabled to have thrown herself off from the cliff at the castle into the sea, and to have been drowned. Nenci states that the island of Ilva acquired its name from this romantic lady. (*Storia dell' Isola dell' Elba.*) *Suum cuique;* I do not vouch for the accuracy of this tale. My only object in bringing forward these remarks is believing they may possibly serve as a guide to others in forming a judgment as to the age of the slags found close to the ruins, for I think the identity of these tiles from Capo Castello and the others from Rio, show that the mines of Rio were contemporaneous with the ancient fort. It would, indeed, be difficult, without the aid of fragments of antiquities, found buried with the slags scattered over the island, to form the least clue as to their age; but, reasoning from circumstantial evidence, I consider it probable that they are exceedingly ancient, dating at least from the days of the Roman kingdom or republic; for my part, I incline to the belief that they may be partly of Etruscan origin, for evidently the island was thickly wooded when the inhabitants smelted their ore so extensively in Elba, and the reason for the subsequent abandonment of these localities, and the shipment of ore to Populonia, as was practised in Strabo's time, was doubtless because wood and charcoal were there procurable at less cost.

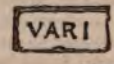


Inscription on Roman tile from Capo Castello, **EUHEMER. QMANIP. S.**

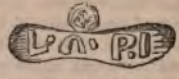


Similar inscription on the tile from Rio, to which are added the words **F. CARSIMARUS.**

On tile from Rio. **RVEVEI. EROTIS.**



Id. id. **VARI.**



Inscription at the bottom of a vase brought by the writer from Capo Castello, **L.A P.I.** (?), the stamp being in the form of a human right foot. Mr. Birch, of the British Museum, has been kind enough to inform me that these may be considered as potter's marks. EUHEMER signifying Ἐυ ἡμέρα, good day; Εροτις, from ἔρως, love, signifying a freed slave. The dates may yet be made out by some one.

The etymology of Portoferrajo, known to the Romans as Ferrara, is *porto*, harbour, *ferrajo*, a smith (or probably better, a smithy).

During my stay, many Etruscan and Roman antiquities were dug up at Portoferrajo, chiefly lamps and vases.

To bid adieu to the times of fable, more positive records are extant from the 6th century, when Elba with its iron mines pertained to the civil and ecclesiastical government of Populonia, a city only 20 miles distant. Other documents inform us that in the 11th century Elba belonged to the Pisan Republic, from whom it was taken in 1290 by the Genoese. For nearly 20 years the Pisans were very desirous of recovering so valuable a portion of their territory; at length, in 1309, while Count Federigo di Montefeltro was *Podestà* and Captain-General of the Pisans, the Genoese dictated a treaty, by which they might be reinstated in possession, on payment of 56,000 gold florins (*fiorini d'oro*). The merchants and citizens of Pisa were obliged to come forward and aid in raising so large a sum of money, for which they received in exchange part of the iron ore of Rio mine. Several items of these payments are recorded in the Arch. Dipl. Flor. (*Charte del Monastero di S. Michele in Borgo di Pisa.*) Thus, a certain Luparello, of Pisa, paid down 5,000 gold florins on the 11th August, 1311 (Pisan style). From another passage we glean two interesting facts—the antiquity of the present mode of weighing by *centi*, and the value of the ore in the 14th century; thus, Bartolo del fu Jacobo da Montemagno made a public declaration before the procurator-general of a commercial company entrusted with the sale of the Elban ores for the benefit of the commune of Pisa, that he had received three *centi* of ore, each weighing 33,333⅓ Tuscan lbs., for 180 gold florins, or at the rate of 60 gold florins per *cento* [5⅗ florins, per ton English], and thereby agreed to pay down the said sum within six months; (Arch. Dipl. Flor.), quoted by Repetti (*Dizionario Storico della Toscana*, tom. ii., p. 591).

Elba was governed by the Pisans down to 1399, when Gherardo di Appiani, their Captain-General, sold the Pisan territory to Giovanni Galeazzo Visconti, duke of Milan, for which he was very handsomely paid in cash and allowed to enjoy free power of governing the remoter parts of the Maremme, with Piombino, Elba, and Pianosa.

What was the condition of the Elban mines immediately previous to 1544 I cannot very positively say; at that time everything must have been brought to a sudden stand by an invasion of the island by the Turks. Charles V., having beseiged and taken Tunis, brought back Sinan, son of the Commander-in-Chief of the Sultan's fleet, and of a slave from Grassera, a town in Elba. Returning with him to Tuscany, young Sinan was baptized at Piombino. Barbarossa, King of Algiers, came to claim him, but was informed that the demand was useless, since he had been baptised in the Christian faith. Prince Appiani, however, assured the Mussulman that he should be treated like a son and not as a slave. After long and fruitless deliberations Barbarossa ordered his troops to land in Elba. They first devastated Capoliveri, the terror-striken inhabitants flying to the mountains and woods, or hiding themselves in caves from their pursuers, so that most of them perished. The castle of Volterrajo was then attacked, but unsuccessfully, so they turned towards the castle of Lucceri, which they blew up. Appiani now thought of restoring Sinan to prevent the utter destruction of the island. Treating with Barbarossa he sent a galley to Piombino to fetch the youth. The two parties met off Cape della Vita, while Barbarossa, embracing the young man, took him into Portoferrajo, amid the wild demonstrations of joy of the barbarians. (Nenci, *op. cit.*) Capoliveri was so frequently a prey to the Mahometan pirates that it was walled in; and on one occasion it stood a siege of three days. The inhabitants were continually thinned by such invasions, which must have materially influenced the working of the mines.

Portoferrajo subsequently fell into the hands of Cosmo I., who fortified it. However, the Spaniards, in 1602, built the fort of Longone, during the reign of Philip III., In all probability they worked the mine of Terra Nera, which is within range of the guns of the fort; this could be ascertained by searching the Spanish chronicles. Longone sustained a desperate siege from the French, to whom it was given up in 1646. Four years afterwards, in 1650, the Spaniards attacked the fortress, and obliged the French to capitulate. Meanwhile the Princes Appiani were succeeded in the possession of the iron mines by the Princes Ludovisi and Ludovisi-Boncompagni, of Piombino. Still it appears that Terra Nera belonged to the Bourbons down to the last century, because Ferdinand IV. transferred it to the Prince of Piombino on receipt of twelve gold *posati*. (Nenci.) On the 28th of March, 1801, by the treaty of Florence, Ferdinand IV., King of the Two Sicilies, gave up Longone and the portion of Elba belonging to the Prince of Piombino to the Emperor Napoleon I., while soon afterwards, in 1802, France received the remaining portion of Elba by the Treaty of Amiens. Governed successively by the Republic and the Empire, in 1809, Elba, together with the rest of Tuscany, was given over to Eliza, the sister of the Emperor. (Repetti; *Dizionario Storico*, tom. ii., p. 592.) For about ten months (from May 3rd, 1814, to February 26, 1815), Elba belonged to Napoleon, while exiled from the continent of Europe. In this little empire he strove to promote the good of the inhabitants, by making roads and working the white marbles near Longone, and doubtless

the iron mine of Rio was not overlooked by that great man. By the treaty of Vienna in 1815, Elba with its mines reverted to the Grand Duchy of Tuscany, and the Government only ceded the right of extracting ore in 1851. Such is a concise summary of the various political events by which the Elban iron mines have been more or less influenced.

Rio Mine.—The best bird's-eye view of this mine, which has for so many centuries furnished its successive owners with as much ore as ever they required, is obtained from the village of Rio, from whence we see the quarries excavated at various levels on the side of the hill down to the Val di Rio, through which a little brook flows towards the Marina, and forms the boundary; the greater part of the southern slope is covered with a prodigious vein or veins of specular peroxide of iron, which, traversing the rocks, as before-mentioned, so as invariably to metamorphose them in contact with the ore, the term dyke, as Savi and Meneghini have described it, may, perhaps, be more properly employed than vein.

That the dykes of iron ore at Rio were formed by igneous action, I have no doubt, from the fact that specular iron is formed in the volcanos at the present day, such as Vesuvius and Ascension. Hausmann describes specular iron artificially produced in an iron furnace at the works of Altenau, in the Hartz, which he considers to have crystallized out from the molten mass; the crystals were precisely similar to that of Rio, a most important fact, because in volcanos they are invariably very minute, and readily to be distinguished from specimens of Elban specular iron. (Hausmann; *Beiträge zur metallurgischen Kristalkunde*, p. 18.) In parts the depth of the workings, as near as I could judge, cannot be less than 120 feet. Looking down towards the mine from Rio, imaginary lines can be drawn across the artificial cavities, and by following what was the original slope of the hill, we can appreciate to what an extent the ore has been extracted. The subjacent beds are hard metamorphosed Palæozoic rocks, generally known in Italy as *Verrucano;* the superincumbent strata, when present, are dolomitic limestones. Associated with the *verrucano* is another bed, of only local importance, provincially termed *Bianchetto;* it is a species of metamorphosed talcose schist. The base of the veins at Vigneria, Capo Calamita, and Capo Pero likewise rests on Palæozoic rocks. Many have hastily considered that the ore at Rio was a regularly stratified deposit, but Savi has clearly shown the fallacy of such a conclusion. Nor did I for a moment doubt the fact of the ore forming veins in the rock, though I had not then the advantage of reading Professor Savi's excellent memoir on the subject, for along the sea cliff, extending from Cape Pero to the Marina di Rio, an infinite number of strings of iron ore are seen in the *verrucano*, some not more than a few inches in width, others several feet, generally much more prominent than the adjacent whitish quartzose conglomerate, here formed of fragments, compactly agglutinized together by the fusion of the more easily liquifiable portion. The method by which the ore is worked at Rio is apt to give us a false idea, and leave an impression that it occurs in vast *conche* or basins. This is owing to the system of discontinuing a working in a given spot where the ore becomes a little less productive, and commencing elsewhere. Such changes in the quality of the ore do not frequently occur at Rio, so that these basin-shaped workings are of enormous dimensions: little engineering skill was expended to keep the mine in operation until within the last year or two; it needs but to follow the ore where it is of good quality and most abundant.

When crystallized the specular iron is excessively hard, and can only be excavated with gunpowder. One particular spot, now no longer worked, was pointed out to me, whence the most beautiful specimens have been obtained for many European cabinets. The size of the crystals is occasionally 1½ inches, between them the ore is very dense and massive, and has a strongly metallic lustre; the colour is steel-grey, and frequently the edges of the crystals are sharp enough to produce severe but clean cuts in the hand if taken up carelessly. The purest ore is called *Vena ferrata;* sometimes quartz crystals abound along with the specular iron, in which case it is known as *Marmigno;* in places the ore is squameous and friable, whence it derives the name micaceous iron ore (*Vena luccica*), which is soft enough to be dug out with pickaxes, as at the Polverino, where it occurs for the length of one hundred feet, and a depth of 40 feet, resting immediately on yellow and dark ochres. The crumbling nature of the mineral at the Polverino renders it easy to remove, and be at once shovelled into the panniers and loaded on the donkeys. The specular peroxide of iron or oligist—of which all these ores are but varieties—passes in a few places into rich hæmatite; it is chiefly powdery, being red ochre, apparently formed by a re-arrangement of the particles of the mineral, for in chemical composition they are identical. The ochres are frequently seen between the interstices of oligist or the brown hæmatite, and form the variety called *Sanguinaccio.* I did not see much brown hæmatite (*Vena cieca*) at Rio, but of the more earthy varieties, which constitute the abundant yellow ochres, or *Terra gialla* of commerce, many shades are procurable, from which pigments might be made with considerable advantage, to compete with the celebrated Sienna earths. Some are already employed in fresco-painting. A kind, very

closely resembling raw Sienna, is washed in a building near the top of the hill, and a portion being burnt forms red ochre. A whitish pigment, for fresco-painting, is prepared from the decomposed *bianchetto*.

Accompanying the *bianchetto* in various parts of the mine are immense masses of iron pyrites, mostly in a state of decomposition and disintegration: on taking up a lump in the hand it falls to pieces, the agglomerated mass of crystals separating into its individual members, so that it is easy to pick out little octohedral crystals of the size of a pea. I noticed that when they have become larger they usually assume hemihedral forms, such as the pentagonal dodecahedron, in a few rare instances with axes as much as an inch and a half in length. It is not an easy matter to find such perfect crystals, even after an entire day's search; they are most commonly grouped together in a very confused manner; this pyrites, known as *Marchesite*, has been all thrown away up to this period, though I believe the recent improvements in the manufacture of sulphuric acid would fully justify the expense of extracting the Elban pyrites for economic purposes.

The ancient mode of smelting iron was such as to prevent the employment of small ore, which must naturally be removed, whether required or not; nor are the Tuscan and French furnaces, employing charcoal, adapted for this purpose to the present day; thus mounds or even little hills of "rubbish," so to translate the word *Gettate*, have accumulated for ages, and been constantly increasing until very recently. The prodigious quantity of *gettate* at Rio and Rio Albano is the first thing which strikes the stranger visiting those mines. The ancients, and even the miners of later days, evidently chose out all the good lumps, rejecting whatever was of a smaller size than a pigeon's egg, together with the whole of the dust arising from the crumbling of the scaly or micaceous ore—in some cases a large per centage: in the course of their excavations they found it most convenient to place their rubbish as much as possible in one spot on the brow of the hill. M. Ponsard has calculated that there are 8,000,000 tons of this rubbish which might be immediately turned to account. The *gettate* form a loose mass, which may be occasionally dug out with a pickaxe and shovel, though sometimes the rain-water, percolating to a small depth produces a hard superficial epigenic breccia, the angular dust and fragments of oxide of iron presenting themselves under the most favourable circumstances for forming a hard ferruginous cement. The English blast furnaces have proved eminently useful for the employment of this material, and thus a secondary extraction on an extensive scale has been commenced, exhibiting for the first time any engineering skill. A shaft, *pozzo dell' ornello*, lately sunk to the depth of 150 feet through the *gettate*, is used to lower the ore in the immediate neighbourhood by means of waggons. From the bottom of the shaft a capacious gallery, rendered secure by good masonry, leads to the *Laveria*, or dressing-house, whence it is called *Galleria della laveria*: it is of great assistance in conveying any earthy hæmatite and *gettate* to the washing troughs. The waggons are lowered by means of an iron wire rope, now much corroded from the quantity of sulphuric acid in the mineral waters—a defect which might be easily rectified by having the wire galvanized. A second shaft is in progress, higher up the hill, for lowering the ore to the dressing-house; it is double, one half being intended for the *gettate*, the other for the lumps of ore; its depth will be 360 feet; the ground through which it has to pass being very pulverulent, and chiefly composed of *gettate*, the sides have been walled in. As the dressing-house requires a considerable body of water, and as the torrent running by it through the Val di Rio is perfectly dry in summer, a large reservoir has been constructed at the upper part of the mine, not far from the ochre sheds. I must here, however, mention that, as the specular iron does not require any washing or other treatment preparatory to being thrown into the furnaces, the dressing-house is only employed for a comparatively small proportion of the ore.

I fear I shall fail to convey to the reader who has not visited Elba a just idea of the truly wonderful mine of Rio. There are copper mines in Cornwall which attain the depth of 2,000 feet,* and the neighbourhood of Redruth presents leagues of "shafts," "levels," and "winzes," but we cannot take a general view of all those extensive workings, otherwise than by a map, since those mines are little else than a series of tunnels and chimneys through the rock; any one going down one of them can scarcely ever see a hundred yards before him. At Rio, on the other hand, where the whole of the ore is excavated at the surface, as in an ordinary stone quarry, by open cast (*cava all'aria aperta*), we can form a better conception of the quantity of material which has been extracted by human agency. The best comparison which occurs to me among English mines, is that of Carclaze, near St. Austle, whence tin is supposed to have been obtained since the days of the Roman sway in Britain. There is, however, this great difference, Carclaze is a single vast excavation: the immense quarries at Rio are in no way inferior in point of size, but instead of there being only one, a considerable number are seen, which will, possibly, in the

* Tresavean mine is 2,100 feet deep; the United mines, in Gwennap, 1,800 feet; Fowey Consols, 1,680 feet.

lapse of time be thrown into one vast quarry, the entire face of the hill being scooped away.

Such irregularity and want of system in the workings being decidedly the worst plan that could have been adopted, causing as it does great waste, the various reasons which have led to its employment at different epochs may be briefly alluded to. The Etruscans, Tyrrhenians, and Romans no doubt found it to their advantage to extract only that quality of ore which they were enabled to smelt with most ease in their little charcoal furnaces. In those days the mines were doubtless ever and anon relinquished on account of wars, invasions, and piratical expeditions, so that the new comers chose such fresh places as most pleased them. In the dark ages enterprise was at a low ebb: I should imagine that those who then obtained ore from Elba only excavated it on a small scale, several persons simultaneously working in different parts at a time when companies were not common. In the days of the Italian republics gunpowder was not used in mines, consequently, much of the ore must still have been too hard to work, as proved by the discovery of rich portions of the vein of specular iron of the most compact variety, since laid bare by the removal of the "rubbish." Thus the same desultory system was carried on. Even within the reign of Leopold II., during the time that the Tuscan Government administered the mines for themselves, not the slightest trouble was taken to follow the more civilised arrangements adopted in other countries. They paid nothing for monopoly of the mine, and consequently nearly everything was clear gain. Lastly; the present company are completely shackled, and almost driven to keep up much of the primitive method of mining, from the enormous tax saddled on them by the Government, in addition to the sum of £20,000 annually required to be paid for the rent of the mines.

The scene I am about to describe is one of so primitive a character, that, thanks to the advance of civilization, it is seldom to be matched in Europe. I mention it as the condition of things in 1859, persuaded that future visitors will find that effectual steps have already been taken towards improvement.

About 130 *sommarj*, or beasts of burden, chiefly donkeys, were employed to convey the ore to the deposit, *scottiere*, on the beach at the Marino di Rio. Each carried about 333 Tuscan lbs. (250lbs. English). As the whole distance is downhill, with this load the unfortunate creatures were scarcely able to lift their feet off the ground, but tottered along in the most pitiable manner. The sight can scarcely be called picturesque. Imagine some 30 or 40 donkeys, each bearing the honourable wounds he has acquired in the service, such as a raw knee, a blind eye, bleeding loins, or some similar distinction. He was *loaded* with as much as his wooden-frame panniers could carry, and these were prevented from falling over his head when he stumbled by a tight rope crupper, which, during the whole journey down hill was kept in a most unnatural state of tension. A little unshod urchin ran alongside, inflicting occasional blows on the head of his charge, unheeded, however, by the poor jaded animals, which needed no guidance, as they were so accustomed to their duty that they sagaciously pursued their path, and only stopped before the piles of ore at the beach. They were barely able to do more than clear the ground with their legs, so that their muscles were kept continually on the stretch. While I have watched these trains of asses, now and then an unfortunate beast had to stop from sheer exhaustion, in order to gain a little strength. One fairly broke down under the weight of the panniers, which, resting on the ground on either side, pinned him down. For some time no one went to his assistance, and there he remained until finally unloaded. The price paid for bringing down the ore was 24 *quattrini*, 3½d., for a *peso*, formed of two loads. Ten journeys were accomplished on an average daily.

Hitherto, only the washed ores are lowered through the shaft to the *laveria*, from whence a tramway, 400 or 500 yards in length, conveys it to the common deposit, where it is tilted out from the waggons.

A common wooden jetty is formed at the Marina di Rio, and when a vessel arrives a most animated scene ensues. The men abandon their ordinary occupation and crowd round a weighing machine supported on three poles. A motley group of three or four dozen men and boys assemble with baskets of all sizes, the load of each individual being proportionate to his strength, the boys only carrying a single lump on their heads. Starting off in a single file for the jetty, they successively drop their burden into the hold of the vessel, and return along parallel planks. Such is the amazing celerity of the operation, that a vessel of 100 tons burden can be loaded in a couple of hours, when the bustle is succeeded by the usual quiet. It will be scarcely credited that, not only was there *no road to Portoferrajo*, the chief town in the island, a distance of some nine miles, but *no wheel carriage* at the important village of Marina di Rio, up to 1859. The bridle path which leads between these important places was so badly planned on the very level of the mountain torrent, through the Val di Rio, as to have been completely destroyed for some distance by the floods of the winter of 1858.

Vigneria Mine is a very small one, and on the sea shore. Being formed on the slope of the hill facing the beach, a tramroad about 200 yards in length conveys the ore to large mounds,

whence it is taken in small boats to the common deposit at the Marino di Rio. The men who load these boats enter the water up to the middle, and then upset their baskets. The *cappello*, or superficial covering over the ore, is about 10 feet thick at this place, and chiefly composed of ferriferous earth. As a general rule in all the Elban mines, where there is any *cappello* at all, it does not exceed that depth, and is frequently reduced to much less. The ore is specular iron, as at Rio, and is very easily removed. In some parts of the mine a large quantity of decomposing iron pyrites occurs in large veins, but not mixed with the ore.

The depth of the vein is considerable; it rests on hard Palæozoic quartzose rocks, as at Rio.

In August, 1858, during the terrific inundation to which I have alluded, the strata separated by the lodgment of a large quantity of water above the more impermeable beds. A huge mass of rock became detached for a length of several hundred yards and a considerable width. When I was in Elba a landslip had only commenced, threatening to increase after the first heavy fall of rain. A house, placed on the very edge of this perpendicular precipice, narrowly escaped being swallowed up in the yawning gulf between. Such landslips are likely to take place at this mine whenever there is an abundance of rain in the eastern part of the island, for as the strata dips towards the water, the superincumbent mass slides forward.

Excellent medicinal mineral springs issue from the pyrites vein; they are strongly acidulated with sulphuric acid, have a nice refreshing taste, and are much prized by the Elbans, who resort to them when afflicted with numerous disorders. Other springs are ferruginous, and are esteemed very strengthening; these are met with more commonly both here and at Rio. Were the sulphurous springs to occur in this country in so pretty and healthy a spot, I am persuaded that, instead of being allowed to flow uncared-for into the sea, they would soon be enclosed, and Rio become a *rendezvous* for invalids, who would have no reason to dread the malaria so prevalent only 15 miles distant, on the opposite mainland.

Rio Albano Mine is situated at Capo Pero, where a portion of the vein or dyke actually runs out for 20 or 30 feet into deep water, and forms a natural pier, at which large vessels can load directly, which is an inestimable convenience. The iron ore, which may be 30 feet deep opposite the pier, rests on *Verrucano* strata, and dips towards the sea at an angle of 20° or 30°. This *verrucano* is a whitish quartzose, crystalline conglomerate, distinguished as *Anagenite*, and often traversed by minute strings of specular iron. The loose material forming the *cappello* is ferruginous, and constitutes a kind of soil. The ore is chiefly specular iron, but a large quantity of brown hæmatite is extracted in places; this goes by the name of *Vena cieca*. In some parts of the mine I procured stalactitical specimens which had formed recently round pieces of stick, &c.; they occasionally assume very beautiful irridescent colours and the most elegant forms. The ancients observed this phenomenon of recently-produced stalactitical hæmatite, but not knowing that it was simply the result of the deposits of ferruginous springs, had a notion that the mine was constantly being replenished as soon as the ore was dug out; Strabo, apparently, gave credence to this argument, as he recorded in the brief description he has left us of the Elban mines. The *vena cieca* produces very excellent soft iron for castings: *vena luccica* also occurs in smaller quantities. They have been already working at Capo Pero for about ten years.

An ancient excavation is seen above the present one, on the sea cliff, and a line of similar ones is reached on ascending the hill. We must stand at a short distance, on some eminence, and look down, in order more easily to see how the surface has been scooped out in numerous places. I entered a vineyard formed in one of these hollows; on two sides is a cliff, and in the centre rises an isolated column-like rock—all forming part of the iron vein. It is, in fact, an ancient mine; the central portion was, doubtless, left because it consisted of poorer or harder ore than the surrounding parts. The soil under the ore could not certainly have accumulated sufficiently to have fitted the place for a fruit garden, in which large trees are thriving, in less than many centuries. The ancients picked out many such favourable spots for mining for a long distance along the edge of the hill. Within 100 yards of the place where the miners are now working, I observed a line of cliff 10 to 20 feet high, and 100 feet above the sea-level. Being entirely overgrown with brushwood and vegetation it might be passed over without close inspection. When examined, by chipping off pieces with a hammer, it is seen to be likewise composed of specular iron, and in many parts bears evidence of having been artificially dug out; besides which, the abundance of *gettate* all around prove the agency of man.

It would repay the trouble of the walk, to stroll along the beach in returning to the Marina di Rio, in order to observe the small veins of specular iron in the cliff. At other times we meet with large boulders of oligist, of a cubic yard or more, strewed on the beach. These stray lumps are sold under the name of *Ferrino* (literally little iron, in contradistinction to the ore found *in situ*).

Where the current sets in, the fine sand on the beach is covered with a layer of minute scales of micaceous iron ore, *Puletta*, thrown

up during storms. These sea-washed ores are of the greatest purity, and are eagerly sought after by the Neapolitan founders.

I scarcely know which is the prettiest sight, the minute spangles of specular iron which cover the paths from Rio to the water's-edge, shining with intense brilliancy in the blaze of the sun, and successively presenting their tiny faces to one in passing onwards, or their more silvery appearance seen through the blue Mediterranean, unruffled by waves, but just sufficiently rippled by the balmy summer's zephyrs to keep their little crystalline surfaces in never-ceasing motion, which might inspire a poet with the idea that the sea was resting her bosom on a bed of gems.

Terra Nera Mine.—Pursuing the footpath from the Marina di Rio inland, over Monte Arco, the outcrops of iron veins are frequently seen. At the bottom of a water-course, half a mile before arriving at the Gulf of Longone, one of these may be distinctly traced for some distance; it is situated in a vineyard, where it is very conspicuous, standing up boldly as much as 6 feet above the ground, though it has become rusty and brown at the surface. There can be little doubt than even here there must be inestimable mineral wealth lying not far below the surface.

On reaching Terra Nera we find a steep declivity before us. The mine extends from an elevation of 200 or 300 feet down to the water's edge. The ore is excavated in basins (*conche*), within a few feet of the surface. The dyke is much more irregular than at Rio, for in the midst of some splendid mass, offering every prospect of success, the ore suddenly disappears, and it needs much skill to find it again. Doubtless, the dyke was originally continuous, similar to that at Rio, but has become distorted and convulsed during the eruption of serpentine rocks, portions being upheaved, producing faults. As far as I could judge, the specular iron, although partly well crystallized, as at Rio, is mostly of a more dense variety of *vena ferrata*, with minute cellular structure, and is very hard and difficult to break. There are several excavations, each continued down to the rock below, partly a hard, compact, white sandstone, and partly strata belonging to the Oolitic *Scisti varicolori*, described by Savi. A large quantity of *gettate* may be noticed on the slope of the hill below some of the quarries. Scarcely any soil is found on the back of the exposed vein, not even sufficient for grass, therefore the ferriferous district can generally be recognised with ease from a distance, from its dark sterile appearance. There is little no *puletta* on the beach near Terra Nera, attributable to the absence of micaceous ores.

Vessels, as at Capo Pero, load at once from a portion of the dyke which runs out into the sea, where it may be distinctly traced into *many fathoms* of water. Up to the present time there is no proper road from Terra Nera to Longone, about a mile distant. In walking in that direction, we pass a large quantity of slag in deep beds, and a most interesting group of ruined houses built of iron ore in place of stone. I do not think that these houses can be more than 200 years old, nor is there any evidence of Terra Nera mine having been worked before the foundation of the fort of Longone, in the 17th century, otherwise we should find some ancient village in the neighbourhood, which is not the case. I have figured an old rusty pickaxe found at Terra Nera, though I do not think it very instructive as to date; in form it certainly differs from such as are now employed in Elban mines. The slags were probably made from Riese ore, smelted near here. I may say that, although Terra Nera mine is alluded to by Pini, in 1777, the works had been suspended for some years previous to his visit, nor does he mention why only Rio mine was then open. (*Osservazioni mineralogiche sulla Miniera di Ferro di Rio.*)

Capo Calamita Mine.—This ferriferous district, like the preceding ones, is situated on the coast. It is 13 miles from Portoferrajo and 5 from Longone, commencing 2 miles beyond Capoliveri, to which place the road extends: in the latter village, containing a population of 1,200 inhabitants, the miners and agent live.

The territory stretches for a mile along the coast, being bounded by the little torrents Serchio and Romajola, and is confined to the southern slope of Monte Calamita, in places extended down to the water's edge. The average breadth of this strip is half-a-mile. The highest excavation on Monte Calamita is half-a-mile from the sea. Numerous small open-cast pits have here been made, but to no great depth. The ore presents several qualities, more or less magnetic. A characteristic form in which it occurs is in coarse lenticular grains or globules, dark black, with a dense reddish cement, and difficult to extract. This is splendid ore, and easily smelted by the Catalan process, by which wrought-iron is obtained directly. It is not smelted in Tuscany, but exported to France. Another variety is steel-grey, and compact. A succession of gentle blows being given it with a hammer produces a kind of dust, which remains attached in long needles of great beauty, branching out in various directions for a quarter of an inch in length. All these are called generically *Ferro magnetico*, but the name loadstone, *Calamita*, is restricted to the

more granular lenticular variety, possessing a crystalline structure. Oblong fragments of such ore present decided polarity, as is proved by taking up successively a number of pieces, and bringing them within a short distance of the compass. On entering one of the quarries where the loadstone is worked, within a few yards of the rock the needle is deflected, but on taking up a fragment in the hand it makes the compass swerve round, so that it may be made to revolve as rapidly as desired. I cannot help thinking that the stories about vessels having been inconvenienced by the quantity of magnetic iron at Monte Calamita, are but tales to amuse the listener, for, on particular inquiry of the sailors, I could not find this statement substantiated; and I ascertained for myself that at a short distance the needle was little affected, though probably close under the rocks there might be a very trifling deviation; but who would dream of bringing a vessel under sharp rocks, exposing her to be dashed to pieces?

Descending the hill, the back of the dyke is seen at every step, and loose blocks of ore, more or less rolled, lie among the few stunted heaths and other rock-plants which have succeeded in taking root here. We first come to a quarry of greater dimensions, whence compact and somewhat lamellar specular iron is obtained. It may be readily distinguished from the ores of which I have spoken, and does not crumble under the hand. The crystals when present are small; it is sufficiently spongy and porous to be easy of fusion, and is well adapted for the Tuscan charcoal-fed furnaces. In a few minutes we arrive at an extensive quarry in the face of the rock. It is 50 feet deep, and about 100 feet above the level of the sea, which is within a stone's-throw. One portion yields very dense and superior specular iron, but on the sides of the mass the ore is poorer, and much intermixed with ochre and earthy matters, and iron pyrites, *marchesite*, not occurring higher up the hill. On the surfaces of some of the lumps of specular iron I found a slight coating of crysocolla, a silicate of copper, but none of the miners had any knowledge of the existence of larger quantities of copper ore. Little, if any, quartz is found in these mines. From hence, advancing towards the cape, and walking parallel to the sea, may be observed a large prominent mass of ore, 12 feet high, and as many broad and long, probably containing 1,500 cubic feet, though in a great measure consisting of comparatively poor brown hæmatite.

Cape Calamita is a low prominence, consisting of three points: that in the middle is called Punta nera, the black point, from the dark colour of the ore; it juts out several hundred feet farther than the others, being formed of the hard metalliferous vein, which has been better able to resist the action of the sea than the surrounding limestones. A few hundred feet to the west is the Punta bianca, or white point, so called from the colour ot the metamorphic limestone of which it is composed, while to the east is the Punta rossa, formed of the red hydrated oxide of iron. A large quantity of amphibole or pyroxene is seen at the Punta nera; it passes insensibly into yenite; the crystals of these two materials intimately blending, are only to be distinguished by their colour, the former being greenish or straw-yellow, the latter blackish. Savi says that the pyroxene is due to the metamorphic action of the iron dyke in the process of eruption on the superincumbent altered limestones. The variety of amphibole here met with is known to Italian geologists as *Pirosseno fibroso;* having been much acted on in places by weather and water, it crumbles to pieces at the surface, and is easily washed away by the waves.

To the east of the Punta nera are veins of titaniferous iron, formed of porous masses, in which the minute brilliant crystals endowed with strong metallic lustre are dispersed. I consider that this mineral, added in small quantities to the iron, would be of great value in the manufacture of steel, as it is to the presence of titanium that the steel manufactured from the iron sand of Taranaki, in New Zealand, has lately acquired such repute. Covering the surfaces of fissures in the rock in the same places are found groups of ferriferous garnets, often as large as a pea, but seldom in detached crystals, in which the faces can be clearly made out.

Taking a boat with Sig. Melini—the agent of the company at Capoliveri—and sailing to the westward, I was able to observe the general disposition of the strata; the limestones in contact with the iron veins or dykes have been much upheaved and metamorphosed; farther off their original structure is apparent. About three or four hundred yards from the coast two rocks rise boldly out of deep water: being of nearly similar size, they have obtained the name of the twins—Isole de' Gemini; though only separated by a space of a few fathoms from each other, the structure of these two islets is entirely dissimilar: the inner and smaller one is formed of limestone, like that which rests on the iron, and the beds are much upturned; the outer rock is serpentine, and rises to the height of fifty feet.

Palæozoic strata are discoverable in places under the limestone; they are very hard crystalline rocks, as are all the representatives of the *Verrucano* in Elba. I have alluded to the serpentine and the iron dykes as having contributed to raise these hills, as they doubtless did, but that is not sufficient to account for their present relief, Savi, Meneghini, Cocchi, and others having fully established the fact that the whole of the iron veins in

Elba are of Eocene age, and the serpentine was *nowhere erupted* after the close of the Miocene period; on the other hand, Pleiocene *Panchina* is seen high up the hill in several places between this and Capoliveri. This occasionally consists of coarse sand, such as is produced at the level of the tides, and contains *Pecten* and one or two other genera of littoral shells—the only fossil, I believe, to be found in Elba; the whole is strongly agglutinated by calcareous cement. I observed a deep bed of *panchina* at the beach of the Madonna delle Grazie, three miles N.W. of Capo Calamita, where it forms a hard little cliff on either side of a rivulet. Patches of the same rock are seen in various places near Capoliveri, at considerable elevations.

The depth of the iron ore at Capo Calamita is not known, as it has been worked for so short a period; it is, however, stated to improve in going downwards. Throughout the whole mine no water is obtainable in summer, but the brooks on either side might be turned to advantage in winter in dressing the hæmatite. Hitherto the ore is conveyed on asses (*sommarj*), to a wooden jetty half-way to the Spiaggia della Madonna, but I consider that, *with a little expenditure*, it might be put on board, in fine weather, with far greater advantage, at Capo Calamita itself, where the water is deep close under the rocks.

There is still one locality which I must mention, although the interest attached to it is rather geological than economical—it is at the little coast-guard station at the Torre della Marina di Rio. A dyke of yenite and amphibole of extreme hardness is there seen in the cliff overhanging the sea, in an almost inaccessible position. I was scarcely able to splinter off the least fragment. Occasionally the crystals of yenite are 2½ inches in length, prisms with perfect terminations, but these cannot be procured without much trouble by blasting the rock. I was unable to obtain any yenite with metallic lustre, but only more earthy specimens verging into brown hæmatite.

The importance of the Elban iron mines will be best appreciated by presenting a few reliable statistics. With regard to the produce of the five mines, M. Ulrich informed me that it was sent to various countries, in the following quantities, per annum (see next column):—

Destination.	*Tonnelate.* (Tuscan Tons.)	Variety Used, and Method of Manufacture.
Tuscany: Blast furnaces at Cecina, Follonica, Valpiana	20,000 to 25,000	*Vena ferrata*; porous *Oligisto*. For making cast iron, part of which is subsequently manufactured into malleable iron.
Naples and Genoa	1,500 to 2,000	*Pulleta* and *Ferrino* to Naples, for their Catalan furnaces, also hardest *Vena ferrata*, from Terra Nera, for making iron directly. Naples and Genoa take ⅔ of large ore and ⅓ of dust or fine ore. I understood that they paid 297 francs per *cento*, or £1 1s. 4d. per ton.
France :—Corsica, blast furnaces.	10,000 to 20,000	Magnetic oxide, from Calamita mine. For making cast iron, and subsequently malleable iron.
South of France, blast furnaces	15,000 to 20,000	
Wales, (Newport).	2,000 to 2,500	*Marmigno*; *Gettate*, containing 52 per cent of iron, from Rio and Rio Albano. The price of the *Gettate* is 116 to 125 francs per *cento*, or 8s. 3d. to 9s. per ton. Employed for the manufacture of steel.
Hitherto unused	... ...	Titaniferous iron.
,, ,,	... ...	Lievrite, or *Yenite*.
,, ,,	... ...	Iron pyrites, *Marchesite*.

In 1777, Ermenegildo Pini wrote his *Osservazioni sulla Miniera di Ferro di Rio*, from p. 66 of which I extract the following particulars:—110 workmen were employed under the direction of a *Caporale* and *sotto Caporale*, superintended by the *Ministro della Miniera*, whose duty it was to see to the shipment and sale of the ore. Lastly, the Prince of Piombino, to whom this part of Elba then belonged, appointed an *Ispettore Generale* to control the whole of the other officials. The quantity then obtained from Rio alone was 1,250 *centi*, or 13,888¾ tons, which cost from 50 to 52 *scudi* per *cento*, according to circumstances; only the richest was then taken out. The Corsicans were allowed to choose their ore, but the Grand Duke of Tuscany paid higher, having stipulated that he should only be given the best specular iron (*vena ferrata*). Those who bought picked ore, were obliged to take one-fifth small, the rest, on the other hand, being only compelled to buy one-tenth small ore. Pini then enters into a disquisition on the probable amount of ore obtained from these mines, in which he goes minutely into the various calculations. The following are the most useful:—

He estimates the weight of ore extracted from Rio mine before 1777 at	18,030,290 Tuscan tons.
Capacity of the workings in 1777, at.....	397,727,000 cubic Tuscan feet.
Presuming that only ⅓ of the above was good ore, its capacity would be ...	132,575,666 cubic Tuscan feet.
Weight of rich ore per cubic Tuscan foot.....	408 Tuscan pounds.
Which would allow, at the rate of 13,888·75 tons of good ore per annum	1,298 years.

But since in very ancient times Populonia alone is spoken of, while in 1777 there were 17 furnaces in Corsica, and 3 belonging to the Prince of Piombino at Follonica, &c., not to speak of others in the Grand Duchy of Tuscany, the Romagna, Naples, and the Genovesato, he thinks we may reasonably suppose they only obtained one-third of the quantity then raised, which would give, at the rate of 4,629·6 tons per annum ..... 3,894 years.

Otherwise, for the last 2,596 years (Circum temp. Prophet Samuel) an uniform annual yield of good ore, of .... 6,944 tons.

He then predicts that it might last for the supply of Italy for other thousands of years, though he incidentally informs us of how much waste there must have been (fully 20 per cent.) in his time, when metallurgy was in its infancy, for the hard specular ore was supposed to yield rather more than half its weight of iron, whereas chemically it is composed of 70 per cent. of iron and 30 of oxygen, and is always nearly pure. (Pini; *op. cit.*, p. 73.)

Savi thinks that the hills of slag at the Punton' di Scarlino (Val di Pecora), and at the Torre Nuova, at Populonia, indicate that the Elban iron mines not only supplied the whole of Italy in ancient times, but also the rest of Europe.

Produce of the Elban Iron Mines at Various Times.*

1777.—Under the Prince of Piombino; average annual yield for several years, according to Pini, Rio mine then only worked, 13,888 tons; value 4½ to 4⅝ *scudi* per ton.

While under the Tuscan Grand Ducal direct control (official documents):—

1840-1849.—Average yield, Rio mine alone, 26,400 tons; value per ton, 4s. 7d.

Under the joint administration of the new Company (official documents):—

Years.	Quantity of ore extracted.	Quantity of "rubbish," *Gettate*, sent to England.	Mean cost price per ton.	Mean quantity of ore exported or smelted in Tuscany, exclusive of *gettate*.	Consumption in Tuscany during seven years, shewing the countries to which the ore was exported. Mean Annual Sale, 1851-8.
	Tons.	Tons.	*s.* *d.*	Tons.	Tons.
July 1, 1851 to June 30, 1852 ...	21,500	...	4 2¼	22,250	Tuscany, by the Company itself. 21,431
1852–3 ...	38,344	...	2 11	25,480	France..... 18,520
1853–4 ...	61,816	...	2 8	47,381	
1854–5 ...	63,423	...	3 2	59,437	England 3,902
1855–6 ...	58,679	...	3 7	60,297	
1856–7 ...	59,148	...	3 7	72,442	Genoa 2,149
1857–8 ...	55,406	6,366	3 3	49,356	
1858–9 ...	...	5,370	...	...	Naples 2,090
Mean per annum ..	51,188	5,853	3 4	48,092	48,092

In 1859 about 15,000 tons of *gettate* were ordered to be sent to Newport in Wales, otherwise little was done; the French vessels were taken up by the war with Austria, and the Tuscans were more seriously engaged in freeing themselves from a heavy yoke, so that the mines were in a sad state of depression. They were all temporarily suspended in the summer of 1859, with the exception of that of Rio.

I will endeavour to complete the calculations of Pini up to 1859: those in *italics* are only hypothetical.

Supposing that the quantity of ore extracted from the Elban mines did not increase during the whole of the last century, that is to say,

* To enable the reader to form a more accurate idea of the value of the Elban mines, I append the statistics of the produce of some of the principal British iron mines in 1859. (Official.)

	Tons.
Parkside iron mines, Whitehaven; red hæmatite, giving 70·0 of iron	96,107
Eston mines in Cleveland, giving only 20·0 of iron..	500,000
Greatest amount from Cornish iron mines, giving about 30·0 of iron:—	
Restormel	6,915
Gt. Retallack	6,609
Indian Queens	3,027

down to 1801, when Elba came under French rule, we should have an annual yield, up to that time, of 1,388,875 tons. For the next 39 years, up to 1840, when reliable statistics again come in, we may fairly assume the increase to have been uniform, *i.e.*, 320 tons per annum. From these data we may establish the following:—

	Tuscan Tons.
Weight of ore extracted up to 1777 (Pini)	18,030,290
From 1777 *to* 1801; 24 *years, at the uniform rate of* 3,888·75 *tons per annum, as above*	93,330
From 1801 *to* 1840; 39 *years, with progressive increase of* 320 *tons per annum*.....	590,616
From 1840 to 1850; 10 years (official)	264,000
From 1851 to 1858; 7 years (official)	358,316
From 1858 to 1859; 1 year at same rate (probably)	50,000
Estimated yield of the mines of Elba, from the remotest period down to 1859.....	19,386,552
This reduced to English tons would be equal to	19,438,409

As to the future produce of the mines, the ore being really inexhaustible, the amount now raised must rapidly increase when once the kingdom of Italy has become more consolidated.

Years.	Number of Vessels Employed to Convey the Ore from Elba.			Number of Men Employed	
	Under Tuscan Flag.	Under Foreign Flag.	Total.	In the Elban Mines.	In the Iron Works.
	Vessels.	Vessels.	Vessels.		
1777	...	...	...	(Pini) Rio alone..... .. 110	...
Before 1850	...	...	...	(Occasionally) 210	...
1851-2	444	32	476	225	219
1852-3	453	104	557	240	273
1853-4	803	134	937	550	248
1854-5	742	145	887	880	255
1855-6	678	244	922	800	293
1856-7	648	136	784	630	329
1857-8	444	141	585	530	349

The wages of the men at the mines vary from 8d. to 3s. per diem; they work about six hours a day, saints' days, *feste*, excluded, and are divided into several categories:—

Caporali, overseers, equivalent to Cornish "captains."

Scavatori, who remove the earth and superficial cover, with pickaxes and shovels.

Rompitori, who break up the ore with pickaxes and crowbars, so as to be ready to be thrown to the

Martellatori, those who hammer up the larger masses of ore detached from the vein, ready to be laden on asses.

Separatori, whose business it is to separate any *cattivanza* or "bad" parts, such as quartz and gangue, when present.

Sommaraj, donkey boys.

Up to 1851 the men were obliged to relinquish five per cent. of their wages to supply the provident fund, *fondo di soccorso*, and when they became old were pensioned like any other Government servants. This system is no longer in force.

Tools Employed in the Elban Iron Mines.

The ore is weighed in *Centinari*, or *Centi*.

	Tuscan lbs.
1 Donkey-load calculated at ...	333⅓
2 Donkey-loads form 1 *Peso* ...	666⅔
50 *Pesi* equal ..... 1 *Cento* ...	33,333⅓
30 *Centi* ,, ... 1 *Milliore de Libbre*	1,000,000

3,000lbs. equal 1 *Tonnelata* (Tuscan ton).

2,992 Tuscan lbs. are equal to one English ton. I have not considered it necessary to alter the calculations.

Metallurgy of Elban Iron.

We must now cross to the mainland, to follow the smelting operations at Follonica, in the Maremme*. This little village is on the coast, exactly facing Rio, from whence it is fifteen miles distant, and ten from Massa Marittima. These are the most important iron works in Italy. There are three blast furnaces, each capable of containing 18,000 Tuscan pounds, or about six tons of ore; the charge is

350 lbs. of specular iron.
440 lbs. of dense charcoal.

A hot blast of 430° Fahr. is employed. Ninety charges are added daily. They produce 20,000 lbs. to 25,000 lbs. of iron daily (6 tons 14 cwt. to 8 tons 7 cwt.), the ore yielding from 55 to 58 cent. of iron.

The furnaces are tapped every four hours.

Sig. Grabau, a very able engineer, who has had the opportunity of studying the Elban mines later than myself, proposes the partial employment of wood as a fuel, and even of English coal, which costs £1 4s. 10d. at Leghorn, or £1 5s. 3d. at Follonica, exactly the same as the charcoal.

Objects are cast directly from the iron as it flows from the furnace, constituting *Ferro di prima fusione*, otherwise it is made into pig iron, *Ferraccio*. To the foundry is attached a small fitting shop, with machinery for turning, boring, &c.: the iron is said to be particularly well adapted for filing and turning. Among the articles hitherto manufactured of wrought-iron, may be mentioned ploughs, thrashing and reaping machines, &c., and quite recently bar iron and rails. The malleable iron is entirely made with soft charcoal.

In the Italian Exhibition at Florence, a fine collection of specimens of iron from Follonica, of excellent quality, were displayed for the first time. These were subjected to a great variety of tests, such as torsion, plication, boring, &c., but the greatest novelty was the manganiferous pig-iron, containing 5 per cent. of manganese. This remarkable product, very analogous to the German *Spiegeleisen*, presents beautiful crystalline fractures, the faces being 2 or 2½ inches across. Another object of great interest was the bar-iron which M. Ponsard sent as the produce of the new rolls he has set up at Follonica, among which were bars with graceful scrolls, for ornamental purposes. M. Ponsard has now begun to employ the Tertiary lignite of Montebamboli for the puddling furnaces, where the metal not being in contact with the fuel, the sulphur it contains is not detrimental; but wood-charcoal has to be employed for the fusion of the ores as before. The castings exhibited from this establishment were very clean and creditable.

Abundance of water is supplied, even during summer, by a powerful mill-stream; there is sufficient to give blast and turn wheels, &c. A pier has been made at the beach, for better landing the ores, which are conveyed to the foundry by a new tramroad.

Great improvements have lately been made in these works. From the first conversation I had with M. Ponsard, in 1859, I felt convinced he was determined to give an impetus to the entire establishment; till the time of his arrival there was no such a thing as an ordinary plan of the premises. He has lately adopted the plan of roasting the ores previous to smelting them. Sig. Grabau gives the following as the cost of smelting the Elban iron ores at Follonica, which will be better than any information of my own which I can present.

Cost of roasting 1 ton of ore :—

	s.	d.
1 cwt. of waste charcoal.....	1	9
Labour	0	11½
Repairs	0	1
Total £2		9½

Loss in roasting, 10 per cent.

Cost of producing a ton of pig iron :—

	£	s.	d.
33⅓ cwt. of roasted ore, at 9s. 3d. per ton.....	0	15	5
25 cwt. of charcoal at 19s. 2d. per ton	2	4	0
Flux	0	0	8½
Labour	0	2	6
General expenses of administration, interest on capital, &c.....	0	5	9½
Total £3	8	5	

The price of English pig iron at Leghorn is :—

	£	s.	d.
Price at Newcastle	2	16	0
Freight to Leghorn.....	0	16	0
Unloading	0	4	5
	£3	16	5

(Grabau; *le miniere dell' Elba, e l'Industria del Ferro in Italia;* pp. 31, 47.)

* The word *Maremme* simply signifies a district bordering on the sea, *mare* the sea; *maremmano* means belonging to the Maremme. The name is, in this instance, applied to a particular geographical tract in Tuscany.

One other furnace is situated at Valpiana, on the road to Massa; a fifth at Cecina, at the mouth of the river of that name, south of Leghorn. All these places are in the most unhealthy localities: Follonica is notoriously the focus of the intermittent fever district. The men can only work from December to June.

The castings made during the last seven years have been entirely sold in Tuscany; the pig-iron, however, has been largely exported.

EXPORTATION OF CAST-IRON MADE FROM ELBAN ORES, BY MESSRS. BASTOGI AND CO., 1851-8.

	Tons.
France	15,907
Piedmont*	12,270
Papal States	9,120
Modena	761
Austria (Trieste)	93
Spain	31
England	20
	38,202

Neither the cast nor the malleable iron pays export duty.

The furnaces of Follonica, Cecina, and Vivarelli smelted, in 1854, about 1,433 tons of ore, employing 55,000 *some* of charcoal, and producing 7,666 tons of pig iron. 2,500 to 3,000 tons were used in the various states of Italy, at an average price of 41 Tuscan lire per *miliajo* = 4s. 1d. per ton; about 330 tons were used for making castings; 4,000 to 4,300 tons were refined in about 40 Tuscan iron works, producing nearly 3,300 tons of iron, which, at an average value of £ *toscane* 17 per ton, was worth 1,700,000, or 56,666 Tuscan lire.

The production of the iron works in various parts of Tuscany and the neighbouring part of Modena in 1854 were as below:—

Locality.	Number of Iron Works.	Produce in tons.
Pistoja (*Florence*)	17	1,833
Pietrasanta (*Lucca*)	5	500
Pescia (*Florence*)	3	300
The Maremme (*Grosseto*).	4	166
Neighbourhood of Carrara and Massa di Carrara.	2	100
Gabbolano, in the Val di Bisenzio	1	100
Loro, in the Val d' Arno	1	100
Tonniella, in the Val di Mersa	1	33
		3,132

Exclusive of the iron works in the Lucchese and those of Vivarelli, Colonna at Pescia. (Ubaldini Peruzzi, *Atti dei Georgofili*, tom. xxiv).

PRODUCTION OF IRON IN TUSCANY FROM THE MINES OF ELBA.†

	Years.	Cast Iron.	Castings.	Bar Iron.	MEAN ANNUAL VALUE OF: Oak Charcoal per *soma*.	Chestnut Charcoal per *soma*.	Cast Iron, Per Ton.	Castings, Per Ton.	Bar Iron, Per Ton.
		Tons.	Tons.	Tons.	s. d.	s. d.	£ s. d.	£ s. d.	£ s. d.
Under the direct Government administration.	1835‡	2,666	...	...	...	...	4 2 0	...	...
	1849	6,212	221	234	4 5⅚	3 4⅔	3 2 2	10 4 6	10 13 7
	1850	5,175	196	241	4 5⅞	3 4	3 6 2	10 17 3	10 8 10
	1851	6,483	123	217	4 5½	3 3⅔	3 0 5	10 17 5	10 0 2
	Mean ...	5,956⅓	180	231	4 5½	3 4⅙	3 2 11	10 13 6	10 7 6
Under Messrs. Bastogi and Co.	July 1 to June 30 1851								
	July 1 to June 30 1852	6,398	106	228	4 6½	3 2⅙	2 18 0	11 11 0	10 0 2
	1852–3	6,744	466	210	4 8	3 2	2 17 5	5 9 0	9 18 8
	1853–4	8,349	81	256	4 6½	3 1½	2 17 0	9 19 0	10 5 2
	1854–5	10,356	194	305	4 5⅝	3 2½	2 19 10	6 0 10	10 0 0
	1855–6	10,476	127	285	5 0⅔	3 2½	3 3 10	9 8 0	10 5 0
	1856–7	10,625	214	287	5 4	3 4⅙	3 4 2	8 16 8	10 5 0
	1857–8	10,705	889	303	5 5½	3 8½	3 5 2	6 18 10	10 1 8
	Mean ...	9,093	296	268	4 9	3 3⅛	3 0 9	8 6 2	10 4 8

* This was previous to the union of the States of Italy.

† The total quantity of iron manufactured in England and Wales has rapidly increased within the last hundred years, from an amount which was *actually less* than that now made from Elban mines alone:—

Years.	Tons of Pig Iron.
1740	17,000
1750	22,000
1788	68,000
1840	1,000,000
1859 (Great Britain), from 8,500,000 tons of ore, about	3,500,000

‡ Follonica alone, estimated by Repetti.

Eight Annual Balance Sheets of the Joint Administration of the Tuscan Iron Mines and Smelting Works, from July 1st, 1851, to June 30th, 1859.

DEBTORS.

Financial Year (July 1st to June 30th).	STOCK. Iron ore.	Cast Iron.	Iron Castings.	Bar Iron.	Charcoal.	Plant, *Generi di approvisionamento.*	Planting Trees.	Scrap Iron, English pig Iron, manufactured iron, &c.	Platforms, ventilators, trommels, stabling, &c.	Total Stock.	Cash Account.	Various Debtors.	New Works at Folionica and Rio, plant, machinery, implements, furniture at the several establishments, keep of oxen, ox sheds, etc.	Bonds and acceptances in hand.	ANNUAL TOTAL.
	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
1851-2	5,037 4 7	10,166 11 0	4,958 1 4	2,339 16 6	2,555 8 7	2,894 16 10		...	...	27,961 10 3	2,249 9 9	24,072 8 4	11,867 10 6	3,671 3 10	69,812 11 4
1852-3	7,397 19 0	7,684 17 1	3,266 5 5	1,865 5 1	3,831 15 11	3,540 7 4		...	...	24,253 3 4	417 11 2	45,416 6 9	12,797 14 6	1,635 13 8	87,520 9 6
1853-4	10,265 18 6	3,586 11 1	2,521 8 8	1,987 11 8	3,053 3 10	2,163 10 6	134 14 10	915 10 11	...	24,628 10 0	4,813 11 10	35,531 6 5	15,486 17 9	8,234 15 6	88,695 1 6
1854-5	10,941 2 2	3,297 5 4	2,441 14 0	2,482 11 0	2,613 19 4	2,646 15 6	134 15 2	558 2 10	...	25,116 5 4	151 3 8	64,822 18 8	18,193 15 4	7,276 15 0	115,560 18 0
1855-6	11,460 12 4	3,358 10 8	3,078 18 9	2,241 12 8	3,045 11 4	3,755 4 9	129 7 6	486 3 10	...	27,556 1 10	3,016 2 4	87,799 15 2	17,016 17 6	6,867 12 8	142,256 9 6
1856-7	9,801 8 8	3,599 12 0	none.	2,129 18 7	3,743 11 6	3,886 18 10	130 11 6	477 18 9	3,160 5 6	26,930 5 4	8,420 4 4	105,805 11 6	15,785 18 10	9,632 6 8	166,574 6 8
1857-8	10,796 1 10	5,418 13 4	none.	2,179 19 6	5,219 6 10	3,469 0 0	130 11 6	1,120 2 2		28,333 15 2	8,960 5 6	49,356 11 4	16,720 12 4	10,558 3 2	113,929 7 6

CREDITORS.

Financial Year (July 1st to June 30th).	PERMANENT CAPITAL. Household Goods and Stores. (*Mesuerizie fisse, e Masuali.*)	Machinery and Implements.	Furniture.	Total Permanent Capital.	FLOATING CAPITAL. Stock.	Cash.	Various Creditors.	EXPENSES. Expenses attendant on payment of dividends, including salaries, losses by Exchange, etc.	Reserve Fund, in accordance with contract with the late Government.	Stipulated annual amount paid to the Tuscan Government.	Stipend of the Director-General, Segretogi.	APPORTIONMENT OF THE RESIDUAL AMOUNT, IN ACCORDANCE WITH STATUTES OF THE COMPANY. Government moiety.	Director-General's Share of 5 per cent.	Dividends to be divided among the 24 000 Shareholders, 45 per cent.	NETT RECEIPTS.	GRAND TOTAL.
	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£	£ s. d.	£ s. d.	£ s. d.	£	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
1851-2	4,562 1 0	5,800 18 7	1,433 11 7	11,796 11 2	27,911 4 2	10,000	13,980 3 4	...	266 13 4	20,000	333 6 8	...	...	...	16,124 12 9	69,812 11 4
1852-3	4,562 1 0	5,800 18 7	1,433 11 7	11,796 11 2	27,911 4 2	10,000	28,708 4 8	...	266 13 4	20,000	333 6 8	...	...	...	19,437 16 3	87,520 9 6
1583-4	4,562 1 0	5,800 18 7	1,433 11 7	11,796 11 2	27,911 4 2	10,000	13,471 0 8	594 12 6	266 13 4	20,000	333 6 8	2,160 16 6	108 0 10	2,052 15 8	25,516 5 6	88,695 1 6
1854-5	4,562 1 0	5,800 18 7	1,433 11 7	11,796 11 2	27,911 4 2	10,000	39,899 0 2	563 15 6	266 13 4	20,000	333 6 8	2,395 3 6	119 15 2	2,275 8 4	25,954 2 6	115,560 18 0
1855-6	4,562 1 0	5,800 18 7	1,433 11 7	11,796 11 2	27,911 4 2	10,000	68,125 16 6	246 2 0	266 13 4	20,000	333 6 8	1,788 7 10	89 8 4	1,698 19 6	24,422 17 8	142,256 9 6
1856-7	4,562 1 0	5,800 18 7	1,433 11 7	11,796 11 2	27,911 4 2	10,000	90,890 5 8	193 4 8	266 13 4	20,000	333 6 8	2,591 10 6	129 11 6	2,461 19 0	25,976 5 8	166,574 6 8
57-8	4,562 1 0	5,800 18 7	1,433 11 7	11,796 11 2	27,911 4 2	10,000	38,628 17 6	243 6 8	266 13 4	20,000	333 6 8	2,374 14 0	118 14 8	2,255 19 4	25,592 14 8	113,929 7 6
58-9	...	...	...	...	...	...	...	...	...	...	...	...	...	...	20,843 4 0	...

RECEIPTS.

Financial Year (July 1st to June 30th).	By Discount from various parties.	By iron ore.	By micaceous iron oxide.	By cast iron.	By castings.	By sundry products and difference in various accounts.	By bar iron.	Annual Totals.
	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
1851–2	42 11 4	6,706 18 8	264 4 10	8,109 3 11	145 8 0	455 14 9	1,220 13 9	16,965 15 6
1852–3	268 14 4	8,309 3 5	257 2 2	6,286 14 6	1,317 9 1	835 3 6	991 12 7	20,265 19 10
1853–4	66 3 6	12,973 8 0	357 13 4	10,639 3 4	210 5 4	2,259 17 10	824 18 8	27,331 10 0
1854–5	58 3 0	13,468 9 6	206 6 1	11,730 4 8	742 18 8	2,057 10 0	1,102 12 5	29,398 4 4
1855–6	56 13 8	13,357 12 6	490 10 6	10,365 10 2	224 14 4	3,596 15 4	1,140 10 6	29,232 7 0
1856–7	219 10 10	13,762 4 10	354 9 6	10,635 16 0	661 2 8	6,088 6 2	1,289 18 8	32,931 8 10
1857–8	334 16 4	15,229 3 0	173 11 6	10,467 9 6	885 7 9	8,574 0 4	1,297 11 6	36,881 19 2
1858–9	402 5 8	9,295 1 11	16 13 2	6,808 6 11	1,146 8 4	2,827 12 2	962 12 8	23,261 2 11

EXPENDITURE.

Financial Year (July 1st to June 30th).	Expenses of General Administration.				Total Expenses of General Administration.	To divers parties as discount, loss by Exchange, &c.	Expenses of churches at Ceolen and Valpiano.	Difference in sundry accounts and various expenses.	Nett Receipts.	Annual Totals.
	Pay of employés.	Agent at Florence.	Rent of premises.	Stationery, books, &c.						
	£ s. d.	£	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
1851–2	...	...	...	...	52 9 6	408 2 4	45 1 3	335 9 9	16,124 13 9	16,965 15 7
1852–3	...	...	...	...	317 6 7	235 1 10	43 13 10	232 1 4	19,437 16 3	20,266 19 10
1853–4	242 6 8	40	44 0 0	47 10 4	373 17 0	253 14 8	52 2 10	1,135 10 0	25,516 5 6	27,331 10 0
1854–5	252 6 8	40	44 0 0	51 1 0	387 7 8	282 0 6	62 8 10	2,712 4 10	25,954 2 6	29,398 4 4
1855–6	257 6 8	40	37 17 10	37 19 8	373 4 2	446 6 8	39 3 6	3,950 15 0	24,422 17 8	29,232 7 0
1856–7	271 16 8	40	36 13 4	60 13 1	409 3 1	411 4 0	46 2 0	6,088 14 1	25,976 5 8	32,931 8 10
1857–8	329 6 8	40	55 15 6	45 6 10	470 9 0	219 7 0	62 1 6	10,537 7 0	25,592 14 8	36,881 19 2
1858–9	...	...	...	...	1,744 7 9	109 14 1	50 6 5	513 10 7	20,843 4 0	23,291 2 10

The tables, pages 53 and 54, form a condensed and methodical statement of the expenses and proceeds of the mines of Elba and the smelting works on the Continent. The data are official, and may be implicitly relied on, as emanating from the late Ministry of Finances and Public Works at Florence. I have arranged them in a very much simpler manner than the voluminous original papers, which few would have time or inclination to read, could they even have access to them. The amounts also are expressed in pounds sterling, reckoning, as I have everywhere done, 45 *paoli* = £1 sterling.

From the foregoing Tables it will be seen that the net dividends are at present almost nil; they were, per share of 1,000 Tuscan *lire*:

	Lire Toscane.	Soldi.
In 1853–4	2	11
In 1854–5	2	17
In 1855–6	2	2
In 1856–7	3	2
In 1857–8	2	16

The reasons for the profits being so trifling have been sufficiently alluded to in the course of my paper, for the most casual observer could not attribute it to want of sufficient ore at a very cheap rate.

Some of the heaviest items of expense from 1851 to 1858 may be here specified:

	£	£
Organising the new works at the mines, restoring and building bridges, making donkey roads, and one mile one furlong of tram-roads.	8,240	
Establishments in the Maremma	1,733	
		9,973
Engineering works at Rio mine	10,542	
Building two vessels for conveying the ore regularly to the smelting works	1,300	
Laid out on the establishments in the Maremma [forming part of the permanent capital of the Administration].	3,531	
		15,373
		£25,346

Vannuccio Beringucci, an author of the 16th century, says (*Sulle Miniere dell'Elba*) that in his time there was only one furnace in Tuscany producing malleable iron and steel. Cosmo I. procured from the Quarantotto a law prohibiting the importation of bar and nail iron (*ferro sodo, chiodagini e ferri colati*), and all iron ores; and while he permitted some of the Siennese ironmasters to continue their business, he obliged them to purchase

his ores, monopolising the manufacture of nails. He introduced skilled workmen from Brescia and Bergamo, already celebrated for their treatment of iron ores and the manufacture of fire-arms. [Targioni, *Notizie*, p. 233.] He also erected in the Pistojese (*Florence*), the first blast furnaces made in Tuscany, as well as the iron works of Caldana and Pracchia, near Pietrasanta (*Lucca*) (Prof. Puliti, *Rapporto sull' Esposizione di Firenze*, 1850, p. 171). It was the Medicis who afterwards erected the furnaces of Val Piana and Cecina. In 1630 the plague broke out, and made great ravages amongst the workmen, so that the establishments were nearly destroyed. In spite of many obstacles thrown by the Venetian Republic in the way of the emigration of workmen, many were again bribed over to introduce the manufacture of steel, wire, and tools.

In a manuscript biography of Pietro Antonio Micheli, by Giovanni Targioni Tozzetti, we learn that he travelled, by order of Cosmo III., for sixteen months, in 1708 and 1709, in the Tyrol, Austria, Bohemia, and Thuringia, in order to study the art of making pig-iron, a manufacture hitherto confined to Germany. He learned the secret, having lingered for several weeks under various pretexts about a manufactory, where he made friends with the watchman, feigning himself half-crazed; but by the careful attention he paid to the various operations, the superintendent perceived he was anything but mad; and it was only by bribes and a speedy flight that he preserved his liberty. All these efforts were lost by the death of Micheli, who was never able to overcome the obstacles offered by the officers of the Royal Tuscan Iron Works (*Continuazione degli Atti della Reale Accademia dei Georgofili;* tom. xxix., 1851, p. 501).

The iron trade had dwindled away almost to nothing on the accession of the Lorraine sovereigns, who first gave out the works on lease. Pietro Leopoldo was the first to permit private persons to work in Tuscany. Under the French rule, at which time both the Elban mines and the Tuscan Iron Works were the property of the Prince of Piombino, the Elban Iron Works were made to supply arms for the artillery, to the exclusion of all other branches of manufacture. The protection of iron in Tuscany was removed in 1829; three years was given before bringing this law into execution, and the immediate result was the improvement in the quality of the refined iron and the extended manufacture of objects employed in the industrial arts. (*Rapporto sull' Esposizione di Firenze*, 1850, pp. 173, 177.)

Compared with Elban iron mines, those of the Tuscan mainland are of very little importance, nor are they in activity at the present time. In 1843, M. Bourlon opened the mine of Monte Valerio, below Campiglia. The ore is brown hæmatite. Prof. Meneghini shows it to exist in the form of dykes, traversing the purple and reddish Oolitic schists (*Scisti varjcolori*). Another mine was commenced at Gavorrano, in 1842. In the Apuan Alps magnetic iron of very excellent quality is found in numerous places; thus, two dykes occur about six miles above Seravezza, and one mile from Stazzema, at Buca alla Vena, on the northern flank of the hill, several hundred feet above the level of the valley. The magnetic iron of Stazzema is of a steel-grey tint, and is found in crystalline and somewhat granular masses. These dykes traverse the saccharoidal Liassic marble, and in some places have united the angular fragments, forming an excessively hard and strong breccia with metalliferous cement, but difficult to polish. Savi and Meneghini have explained the formation of amphibolic minerals by the agency of the iron, and conclude the origin of the latter to be eruptive, the intrusion having taken place during the Eocene period, like the dykes at Monte Valerio and Gavorrano. Near the entrance of the gallery, or rather cavern, of Buca alla Vena, I noticed a huge mass of white crystalline marble, which had fallen from above, and was in a state of complete disintegration, so that it crumbled to pieces. This seems to me difficult to account for, as it is sheltered from the action of the sun and rain. Other dykes of magnetic iron occur in the Val di Strettoja. The assays of the iron ores from Monte Arsiccio, near Val di Castello, yield fifty or sixty per cent. of iron.

The iron mines of the Versiglia are of very remote origin. Santini has published an extract from the MS. *Archivio Superiore di Pietrasanta* (Liber 1, rosso 3), which states that the inhabitants demanded a reduction in the price of the Elban iron ore they purchased from the princes of Piombino, for smelting in their works.

The iron mines of Stazzema were in activity in the seventeenth century. At one time there were eighteen mines in these valleys. The ore was smelted at the neighbouring works of Rimagno and Strettoja. In spite of the proprietors offering to sell their own production to the Tuscan Government at the cost price of the Elban iron, they were not allowed to do so, lest they should interfere with the monopoly of the crown, consequently they were obliged to abandon the mines altogether (Targioni Tozzetti, *Viaggi in diverse parti della Toscana;* tom. vi., p. 352). Previous to 1848 an Englishman made some attempt to work the iron vein at Buca alla Vena, and in 1855, Sig. Simi earnestly advocated the importance of re-opening these iron mines, now that the political condition of the country is so different from what it used to be, but hitherto no one has done anything, at which I am rather surprised, since so many iron works are already in existence along the

Vezza, where there is abundance of water for moving the hammers and supplying the blast.

Veins or dykes of magnetic iron abound in the Apuan Alps, and are found in the whole marble district of Carrara, Massa, and Seravezza, as well as on the northern flank of Monte Sagro. They run from north to south; their size varies from a mere line to several metres. Owing to the rugged nature of these mountains it is very difficult to study their geological structure minutely, many places being only accessible to the shepherds.

It would appear that there is an intimate relation between the iron dykes and the conversion of the limestones into the white crystalline marbles which enjoy such great reputation. Some writers have supposed that serpentine eruptions were the cause of this molecular change in the structure of the limestones, but as serpentine is nowhere seen at the surface, it is more probable that the change is produced by the veins of magnetic iron, in contact with which the limestones are always more or less altered according to their size. The marble at Capo Corvo, on the Gulf of Spezia (*Genoa*), is everywhere so pervaded with minute veins of magnetic iron, which have become spathose ore by contact with the carbonate of lime, as to be of no economic value, but to the geologist this locality offers valuable data for explaining the origin of the beds of marble in the entire Apuan Alps.

I am of opinion that at a great depth near Carrara and Seravezza, there are immense dykes of magnetic and specular iron, like that of Elba, the magnetic property of the former kind having greatly influenced the molecular transformation of the rock, the statuary marble with the largest crystalline structure being situated nearest the dykes. Be this as it may, wherever such iron ores are found in any quantity in the Apuan Alps, the Grossetano, or Elba, they are invariably accompanied by saccharoidal white marble. When in smaller proportions the carbonate of iron has combined with the marble and formed a double carbonate of iron and lime, which constitutes the colouring matter of the beautiful yellow Sienna marbles.

The *Roman Iron Mining Company* have exhibited in the Italian Department of the International Exhibition a very beautiful collection of bar iron, chiefly manufactured from Elban ore at their iron works at Tivoli and Terni (*Rome*). The convenient situation of Tivoli, only 18 miles from Rome, will procure it the first place among the national establishments of this kind the moment that city becomes the capital of Italy, when doubtless numerous large manufactories and industrial establishments will rise among the ruins of ancient Roman splendour; hitherto there is no demand for this important metal at Rome, nor the slightest encouragement for the establishment of works of this nature.

CHAPTER VII.

COPPER.

Copper occurs in Central Italy under three distinct conditions:—

A. As veins in sedimentary rocks, accompanied by quartz gangue, and associated with other ores, as in Cornwall.

B. In amphibole or pyroxene, a metamorphosed rock.

C. In serpentine without diallage or *gabbro rosso*, an eruptive rock.

A.—Copper in Stratified Rocks.

Of the copper mines in the sedimentary rocks of Tuscany, I know of none better suited for description than those of the neighbourhood of Massa Marittima (*Grosseto*), where the general direction of the veins is N. W. and S. E.

Capanne Vecchie and Poggio Binda mines, belonging to the *Società anonima delle Capanne Vecchie e Poggio Bindo* are situated in a retired and beautiful spot called the Val *Castrucci*, 3 miles south of Massa Marittima, in the Maremme, surrounded by woods of *cerro* and other species of oak, extensively employed for making charcoal. The ore is found in a large vein, running nearly north and south, filled with a whiteish quartzose gangue, in many places containing minute crystals of iron pyrites disseminated throughout the mass. The dip of the vein is 45° E. Only one shaft has been sunk, the *pozzo Carlo*, which was calculated to cut the vein at the depth of about 66 yards; but after proceeding half that distance they were obliged to stop short on account of the accumulation of an enormous quantity of water. From 8 to 12 yards the vein runs through calcareous schistose rocks, which belong, if I am not mistaken, to the *macigno*, an Eocene formation. At the depth of 22 yards is the *Galleria Alessandra*, passing laterally to the vein of the same name. In proceeding downwards five little veins, ramifications of the principal one, have been already met with. The richest part of the ore is found on the hanging-wall,

or *tetto*. It appears that the vein or dyke (the rocks in the neighbourhood are considered by some geologists to have been subjected to igneous action), is more and more metalliferous as we descend. The size of the principal vein is from 30 to 50 feet. The ore found at the surface was very poor, only yielding ½ per cent. of copper; in proceeding downwards, irregular zones or nests of pyrites were met with, containing 1, then 3, then 5 per cent. of copper. In the prospectus of the company, made in 1855, they only calculated on procuring 1½ per cent. by the best smelting process then known, taking the whole of the ore together. Since then, a large quantity of ore has been extracted at a greater depth, containing 10 to 15 per cent.; within the last three years the ore from the bottom of the mine has yielded 20 to 25 per cent. The dimensions of the zones are from 80 to 120 feet in length, and 6 feet in depth. The length of the gallery by which the vein is worked is 150 yards. Another company has been proceeding from the opposite direction, for the vein is divided among several companies. I might here incidentally mention a word about this division of mining property; were both parties in such cases to amalgamate their interests they would work the ores to far greater advantage, since the drainage-water of one mine must necessarily flow into the levels of the other, to say nothing of the useless expense attendant on the establishment of two smelting-houses, a double quantity of machinery, and two systems of accounts.

Ancient workings may be seen within a few yards of the present shaft, distinguishable by their great irregularity and shallowness, and from being more or less open to the air; I was informed by one of the gentlemen at the mine that some ancient pottery, supposed to be Etruscan, was found in them. The greater part of the ore is copper pyrites, distributed in minute quantities through semi-vitreous quartz. The miners are paid 3·75 francs for a cubic metre, equivalent to about 11s. 6d. per ton; they furnish their own oil and gunpowder, though provided with the necessary tools. Commencing their operations in September, 1846, the former company only worked the mine for the seven winter and spring months up to 1854, when the present gentlemen, Heinzemann and Company, took a lease from them for 40 years, reserving the option of giving up the mine at the expiration of six years, in case they did not feel disposed to continue any longer: since then they have not intermitted during the summer. This year, however, the mine has been lying idle.

The ores are divided into three kinds:—

1st. Hand-picked copper pyrites, containing 20 to 25 per cent of metal.

2nd. Copper pyrites, containing 10 to 15 per cent. of metal.

3rd. Copper pyrites, containing 2 to 3 per cent. of metal.

A ton of ore of 3 per cent. contains 1·075 oz. of silver.

During the first years since the formation of the present company in 1854, Capanne Vecchie produced about 13⅓ tons of ore of the second quality, and 334 tons of the third quality annually, which were dressed, but with considerable waste, at the neighbouring mine of Accesa, the proprietors of the two mines having made an agreement to that effect.

Though the kindness of Sig. Heinzemann, I am able to publish the average cost of producing 1 cwt. of copper at Capanne Vecchie, as estimated some years ago; although I may remind the reader that, the ores now raised being richer, the result is under the mark:—

	£	s.	d.
1. Cost of raising 50 cwt. of ore, yielding after smelting 1 cwt. of copper, inclusive of extraction and separation from gangue	0	12	6
2. Stamping and dressing the above, inclusive of conveyance to and from the establishment at Accesa, as was then the mode of operation, and by which the *slicco* or dressed ore was concentrated to 9 per cent.....	0	17	6
3. Smelting 4½ cwt. of dressed ore to obtain 1 cwt. of rosetta copper.	1	7	6
Thus, the total expenses of raising and smelting 1 cwt. of copper may be estimated at	2	17	6

In this calculation, however, no notice whatever is taken of the expenses incident to the formation or maintenance of the various establishments, the machinery, or administration.

Subsequently Prof. Bechi, and Sig. Haupt, who was engineer of the former company, proposed a new method of treatment for the poorer ores, containing 2 and 3 per cent. of copper, though I do not consider that this method can be established to be the best, until it has stood a longer trial. As the process is not generally known, I will give a sketch of it. The poor ores are placed in large heaps, something like those of Mansfeld, in Prussian Saxony, interstratified with twigs and brushwood. When once properly ignited, the sulphur of the copper pyrites keeps up the combustion, and after three or four weeks of this treatment, the pyrites have become very friable, much concentrated, and consequently poorer in sulphur. The more earthy portion is then stamped and roasted with salt in a large reverberatory furnace (*forno a reverbero*), charged at the top, on the upper floor of the building, so that the ore is raked into the hole, which is then covered up.

Chloride of copper is one of the products, which, being alone soluble to any extent in water, is easily separated, the solution of chloride of copper passing into a reservoir below, where cast iron from the furnaces at Follonica (*ferraccio di prima fusione*), is thrown in, by means of which a large proportion of the copper is precipitated in a metallic state in thin laminæ crystallised on one side, and containing 50 to 80 per cent. of copper. This cement copper (*rame cementato*) is shovelled out and refined directly. That which escapes precipitation by this simple means, passes on to a second tank situated a little below, where quick-lime is added; a double decomposition ensues; insoluble pale blue hydrated oxide of copper is precipitated, presenting at first somewhat the consistency of clay, gradually falling to the bottom, where it accumulates to the depth of a foot or more; the soluble chloride of calcium is then decanted. I presume the chemical changes must be these:—

$$Ca\,O.HO + Cu\,Cl + HO = Cu\,O.2\,HO + Ca\,Cl$$

The oxide of copper contains from 18 to 20 per cent. of metal. After draining, it is dug out with shovels and placed in a small blast furnace (*forno a manica*), along with the richer pyrites, the interior portion of the nodules of ore concentrated during the roasting in heaps, and rich slags from previous operations. These produce a matt (*metallina*), containing 50 per cent. of copper, and a slag; it is again treated to produce a second *metallina* and another slag, and, during the next process, black copper (*rame nero*) is produced, containing 90 per cent. of copper, from which rosetta copper (*rame rosetta*) is obtained by refining. None of the secondary products have hitherto been utilised.

With all the precautions taken, this ingenious system of treatment has not turned out so favourable at this place as might have been anticipated; chloride of copper being so very volatile that 25 cwt. was lost; in fact it is decomposed at 400°. C. In 1859 the smelting on the spot was given up; since then the whole of the ore has been sold.

An analysis of the copper smelted at Capanne Vecchie gave—

Copper	99·50
Iron	0·02
Silver	0·10
Suboxide of copper	0·30
	99·92

The presence of suboxide is intentional, and gives the rosetta copper that beautiful colour whence it derives its name; it is simply the result of prolonged refining.

It would be advisable to produce refined copper in ingots, in the Italian smelting works, since it would sell at a much higher price in England, where the large rosettes are found to be of a very inconvenient size.

Of the richer ore belonging to the first quality, a fresh market has presented itself in Swansea; it has been largely shipped to England. In June, 1860, the quantity of rosetta copper made was estimated at 7 tons; the monthly export of ore was about 23 tons.

Until very recently brushwood or charcoal was the only fuel consumed here, but occupying as it does so large a space, as also being liable to accident from fire, they have lately tried the Tertiary lignite found at Castiani, near Tatti, at the distance of only six miles, over nearly level country, but to which place there is not the most ordinary kind of road. The experiment now being made seems to have answered very well. The lignite is much cheaper than the wood, primitive as is the present mode of transport in ox-waggons, over marshy heaths and through woods.

Wages of miners at Capanne Vecchie (they provide their own lights, and work 12 hours)	17d. to 20d.
Boys in the workings	12d. to 14d.
Dressers	5d. to 10d.

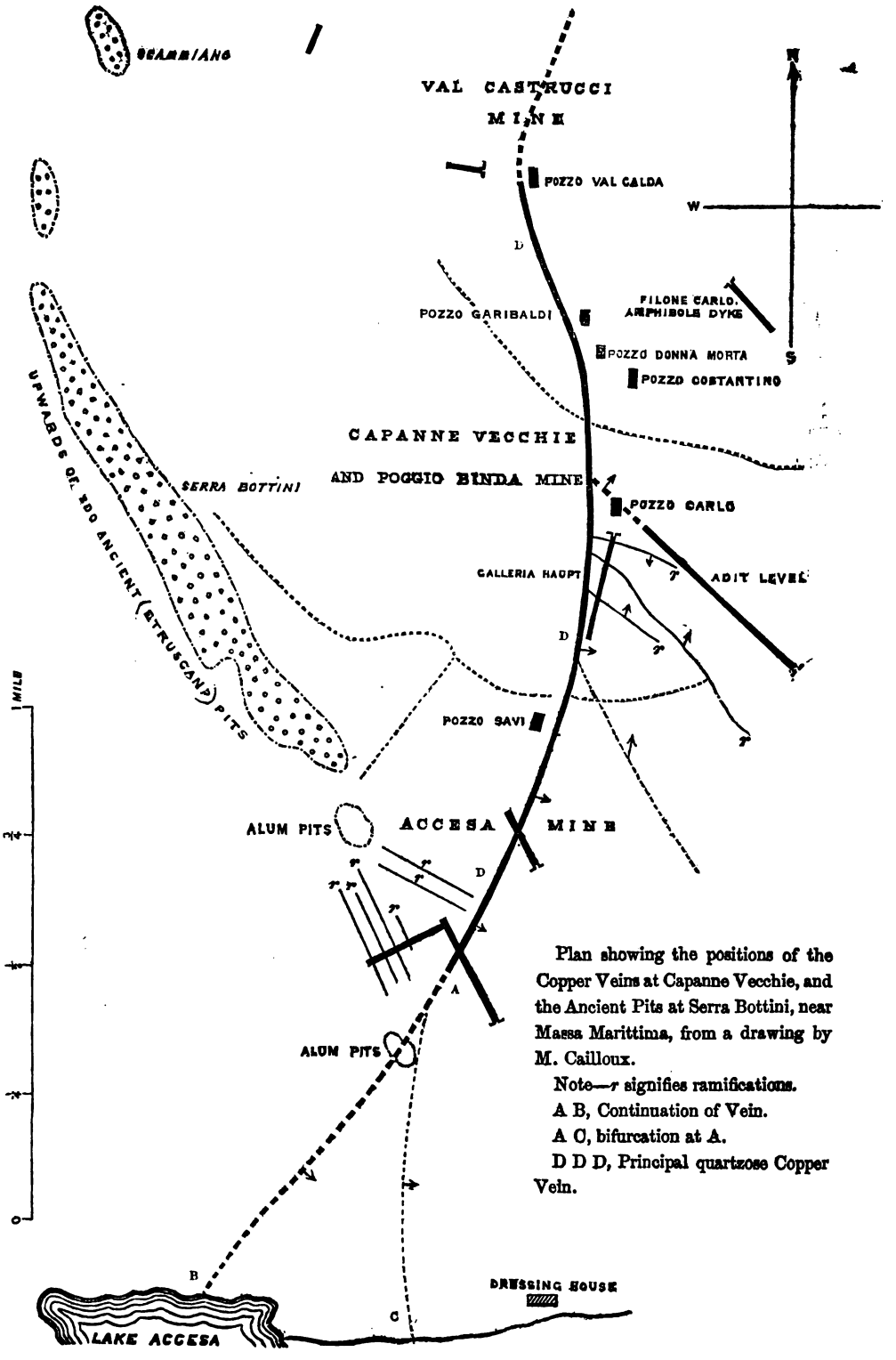
Price of lignite at Capanne Vecchie				
	per ton	£0	18	0
Chestnut charcoal	,,	2	14	0
Oak (*Leccio*) charcoal	,,	3	0	0
Salt	,,	1	2	0
Cast iron	,,	5	4	0
Gunpowder	per cwt.	3	10	0
Sulphur	12s. to	0	14	0
278 cubic feet of oak, *leccio*, &c.	cost	1	0	0

Ten tons of sulphuric acid were consumed monthly at this mine in 1861.

Manganese might be raised from a ramifying vein close by, and would doubtless be eminently useful in the manufacture of glass, but more especially of bleaching powder, to say nothing of the *pozzuolana* and alum abounding in the neighbourhood.

Regarding the machinery, the water is drained from the mine by an 8-horse-power high pressure steam engine, made in London, pumping out 30 cubic feet of water per minute. The draught is supplied to the furnaces by a 20-horse power condensing engine, manufactured at Genoa. The air cylinders, which were erected for the latter in 1859, are 3 feet in diameter and 5 feet long. Up to that period a 3 feet 6 inch disc was employed. The same engine moves the wet and dry stamps (*peste*), such as are used in Cornwall for crushing ores, and also an apparatus for crushing the roasted ore, and the tromps (*trombe a pressione.*)*

* Since writing the above I have been informed that the copper ore now raised is so much richer than it used to be, that the company have quite given up the practice of smelting it at the mine; it is now sent away to be smelted at Swansea, Liverpool, and Hamburg; the reason of thus exporting the ore is the heavy price of the combustible. The freight to Wales is 15s. per ton.



Plan showing the positions of the Copper Veins at Capanne Vecchie, and the Ancient Pits at Serra Bottini, near Massa Marittima, from a drawing by M. Cailloux.

Note—*r* signifies ramifications.

A B, Continuation of Vein.

A C, bifurcation at A.

D D D, Principal quartzose Copper Vein.

The continuation of the vein northwards, towards the Val Calda and Val Castrucci, constitutes the mine of VAL CASTRUCCI, and is worked by the *Società Fenice maremmana*. They have erected three pumps in the shaft called pozzo Costantino, which together throw out 60 cubic feet of water per minute.

Adjoining Capanne Vecchie, to the south, is the mine of ACCESA, belonging to the *Società Metallurgica maremmana*. The mine is in one of those unhealthy places where fevers rage in the summer months, so that the operations have then to be suspended. But the great drawback to these mines, and which has doubtless tried the patience of the engineers, is the immense quantity of water which accumulates in the shafts, especially during winter; but that will speedily be rectified as far as regards the mines of Capanne Vecchie, since an adit level (*galleria di scolo*) is being driven to meet the shaft below the *galleria Alessandra, i.e.*, about 100 feet below the surface of the pit, which is nearly completed.

Numerous ramifications of the principal vein are found on the setts of Capanne Vecchie and Accessa, running more or less parallel to each other, and having a general north-west and south-east course. They incline at an angle of about 50° west of the great vein, and contain calcareous spar as well as quartz. As far as I can judge, it was these ramifications which the ancients worked for a distance of more than a mile, at Serra Bottini and Scabbiano, by means of irregular pits, of which more than 300 are visible. Sig. Rovis, in mapping the country round Massa, has indicated no less than 400 such ancient pits on the Poggio al Montone alone, accompanied for the most part by "burrows," or masses of rubbish containing quartz gangue and copper ore. The accompanying plan is a reduction of the drawings of the engineer of the mine (see preceding page).

Sig. Haupt has prepared a highly interesting series of MSS. plans of the Tuscan mineral veins, indicating 16 mines anciently in operation near Massa Marittima, but none of them worked in 1861; the following is the list of their names:—

Montierino, Scabbiano, Tesoretto } W. of Capanne Vecchie, Val Castrucci, and Carpignano.

Serra Bottini, the property of the former Grand Duke of Tuscany.

Brenna, E. of Capanne Vecchie.

Poggio alle Vidette, Poggio Bertone, Poggio al Montone } E. of Massa.

Serra Bottini settentrionale, 2 miles N.W. of Massa.

Banoletti, Gorgoni, Val d'Aspra, Nicololetta, Stregajo, Porta al ferro, Diacciolini } All in a N. and S. line, and N.E. of Massa.

A short walk inland brings us to the mines of CASTELLACCIA, belonging to the *Società Metallotecnica fiorentina*, the upper part of which produces copper pyrites; the rocks in the neighbourhood are *macigno*. I there noticed some good specimens of ferruginous gangue or "gozzan," with incrustations of malachite and azurite in minute crystals, but, though pure, they were in every instance in very small quantities. It appears to me that in Tuscany these minerals are only found as superficial coatings on oxide of copper or commoner ores, where they have been very recently formed, but never in massive lumps, as in Australia, Africa, or the Government of Perm, in Russia.

ELBA.

Although copper has already been found in four distinct parts of Elba, neither of the veins have been worked for centuries. Until very recently, all the ores of Elba belonged to the government, who neither allowed anyone to work mines, nor troubled themselves about any of them, with the exception of the iron ones. After 10 years' hard struggling, Sig. Luciano Foresi, whose father entertained the Emperor Napoleon I. and his suite on landing at Portoferrajo, in 1814, succeeded in liberating the mineral resources of Elba from government monopoly. The prohibition to work the veins is now no longer in force, and only the iron ores remain in the hands of the government.

Though copper is not now worked in Elba, it was so long before the days of Aristotle: "In Eturiâ ferunt insulam esse quam Æthaliam hodie vocant, in quâ ærifodina est unde æs eruiter, omne scilicit illud ex quo isthuc ærea vasa conflantur. Deficere autem, nec reddere quidquam aliquamdiu; cœterum temporum procursu non æs ut ante sed ferrum provenire, id nempe quo etiamnum utuntur Populorum incolæ vocant." (Aristotle; *περὶ Θαυμασιων ἀκουσμάτων.*)

"It is stated that there is an island in Etruria now called Æthalia, in which there is a copper mine, whence they have obtained the whole of the copper they have employed in making bronze vessels, but now it is abandoned, and has not, for a long time produced anything. The inhabitants of those parts relate that in process of time they no longer procure copper from the island, but only the iron which they are at present in the habit of employing."

STA. LUCIA.—Copper ore is found below and on the east side of the ancient ruin of Sta.

Lucia, a building crowning the summit of a prominent hill 3 miles south of Portoferrajo. It is close to the boundary of the serpentine; Sta. Lucia is on the granite. It is at the junction of two rocks; one of the walls of the vein is formed by whitish porphyritic rock, the other by friable schists. The copper ore was first discovered by accident, while some men were making a circular thrashing-floor on the side of the hill, such as are observed in every farm in Elba. In order to make a level surface, it was necessary to cut away the rock at the back part, when the labourers unexpectedly came on indications of ore. Subsequently Sig. Foresi made an experimental pit to ascertain whether any more could be obtained. The ores are imbedded in quartzose gangue and a siliceous matrix of the hardest kind. Owing to the time which has elapsed since the pit was dug, it has become in a great measure filled with water, so that on descending a few yards I was unable to see the richest portion. The ores found here were copper pyrites, bornite, red oxide of copper, and native copper, all these in masses, and very pure and rich; fibrous malachite and dark blue crystalline azurite were procured, but only in small pieces interspersed in the quartz; I ascertained the size of the outcrop to be three feet, and an estimation of the ore, consisting chiefly of quartz, with small pieces of malachite and azurite, gave 6½ per cent. of copper, though the specimen I submitted to analysis was a poor one.

To work this vein would be very simple; a level could be driven into the hill from the bridle-path in the valley, towards the south-east, for a distance of 800 feet, which would cut it at the depth of about 100 feet, the present road to S. Giovanni, a village on the harbour of Portoferrajo, and only half a mile distant, would afford easy transit for the ores, which might be dressed in the brook running through the valley. Half a mile west of Monte Orello is a pass, of which the Elbans have availed themselves in making a horse path from S. Giovanni to the Gulf of Accona. Two or three hundred yards below the watershed line to the south, some years ago, a shepherd chanced to observe a stone in a field, which, from its green coating, presented an altogether novel appearance to him, and on lifting it up he perceived that it was very heavy; he took it to Sig. Foresi, who recognized it to be a mass of native copper, weighing 47 lbs. avoirdupois. That gentleman proceeded to sink a shaft 200 yards beyond the pass and 20 above the path, and having gone a depth of 16 yards he found more native copper: another excavation close by reached the copper ore at a less depth. These pits are now covered over. Half a mile beyond this we come to another circular thrashing-floor, near a small farm-house. The vein was cut at the back of the floor; the matrix is excessively hard, and contains only the slightest possible traces of ore. The places where I examined the vein all lie more or less in a north and south line for the distance of a mile.

Capo Pomonte.—This little cape is situated at the south-west extremity of Elba, projecting for several hundred yards into the sea; the rocks of which it is composed are serpentine, gabbro, and aphanite, penetrated by quartz veins, in which copper pyrites have been discovered. I traced up three distinct veins from the very sea; two of them may be followed on the face of the cliff for 60 feet; they vary from six inches to a foot in width, but contain so little ore and so much quartz as to be scarcely worthy of mention. Following them along I noticed green carbonate of copper, forming a copious coating on the face of the rock, proceeding from water which had been infiltrated into the vein and had decomposed the ore. About 100 yards from this point is the third vein, from four to five feet thick, traceable for twenty yards, and from which I was able to procure very promising specimens of pyrites; these furnished me on analysis 10¼ per cent. of copper. Copper ore has occasionally been found higher up on the side of the hill.

"Cava dell'Oro."—Two miles west of the Marina di Marciana, under the Concha, is a cliff of *gabbro rosso*, where I could do little more than corroborate the existence of a minute copper vein in it, a few inches broad. A short distance beyond is a mysterious spot, known to the Elbans as the "*Cava dell' Oro*," or gold mine, which I visited in a boat. A small opening is observed in the cliff, through which I entered with a light, the boatmen loudly vociferating all the while, and refusing to go before me, talking a great deal about the foul air, &c. I had heard so often about the places called *Cava dell' Oro*, that I felt anxious to know what grounds there were for the notion of gold being found in Tuscany. I was positively assured by one man that his grandfather had procured gold from this place, and I felt unwilling to be sceptical until I had ascertained the merits of the case. After proceeding some yards, I discovered the secret. It was the purposely obstructed entrance of a gallery, through which I advanced for 300 paces. On coming out, I found the outcrop of a copper pyrites vein, 4 feet wide, embedded in a very hard quartzose matrix; but the ore seemed too poor to work.

Monte Perrone.–Eight miles from Portoferrajo, on the road to the Marina di Marciana, and two from the latter place, a little path branches off towards Monte Perrone, where, at a mile from the coast, we arrive at a spot from whence the village of Poggio is visible directly in a line with Marciana Alta. Traces of ancient mining operations are here seen in every direction; for while I cannot bring for

ward any proofs of the veins I have hitherto described having been ever worked, abundance of "burrows" are here seen all along the face of the hill. The antiquity of the workings is shown by their irregularity and shallowness, and the absence of proper galleries or shafts. They resemble the pits I have studied at Gerfalco,* which have been pronounced to be Etruscan, and I feel no doubt that they were made by that people. About 100 feet below the summit of the mountain is a large hollow, excavated in the vein like a quarry, penetrating some 20 or 30 yards into the rock. It is now so overgrown with brushwood and weeds that it is impossible to see the surface where they worked, but all around are evidences of the nature of the matrix. A kind of loose ferruginous gangue, very similar to Cornish "gozzan," accompanies the ore, and contains pieces of silky malachite in superficial fragments. I found some asbestiform minerals on the burrows, probably derived from *gabbro rosso*. Sig. Begni, some years ago, made several experimental pits, to see if he could cut a vein, but nothing came of the research. Exactly north of Monte Perrone, on the coast, are the Bagni di Marciana. In making the road from Marciana to Portoferrajo, in 1810, some coins of Cæsar Augustus were dug up at the Bagni, which were in all probability Roman baths in his day. Many advantages would be found, were anyone to work the copper ore at Monte Perrone, if the vein once discovered should prove sufficiently good, for the soil is too poor to admit of any culture; the hill is too stony for pasture land, and only a few places afford sufficient earth to admit of brambles and brushwood taking root. Even goats can scarcely find enough to live on, so that the ground is really valueless.

B.—Copper Mines in Amphibole Dykes.

Amphibole, a variety of hornblende, is a crystallized rock, having the same chemical constitution as augite, so commonly found in all recent volcanos, and passes insensibly from olive-green to black, and in composition into Yenite or Ilvaite, a very hard but brittle silicate of iron, almost peculiar to Tuscany; $2\,Fe^2O^3 + 3\,(2\,Fe\,O.\,Si\,O^3) + 3\,Ca\,O.\,2\,Si\,O^3$. It is stated by Mitscherlich, that the difference between the amphibole and augite is simply the result of the former having been slowly cooled, the latter rapidly. Savi considers amphibole to be merely the ordinary rock metamorphosed by metalliferous substances, and to be a secondary product of the eruptions of iron (*Nuovo Giornale de'Letterati di Pisa*, tom. xxvii., p. 68. 1833.)

A mile from Campiglia, in the Maremme, is a largely developed Liassic limestone district, with well-wooded undulating hills and luxuriant valleys, enlivened by rich fruit-gardens and plantations of chestnuts, which attest the fertility of the soil. In the midst of these extensive dykes of amphibole protrude, enclosing in certain places a very great quantity of copper. This ore has been worked in the neighbourhood of Campiglia, at Temperino, about 11 miles from the port of Piombino to which there is an excellent road, and a mile towards S. Vincenzo, where the Emilian road from Pisa to the south passes: the mine belongs to MM. Bourlon et Cie, and lies at a gunshot distance from the road. Although only four miles from the unhealthy district along the coast, the inhabitants of these charming hills and valleys are not in the least degree affected by fever, so that the peasants resort to Campiglia from the fatal plains every evening during the summer, as the sun sets, in order to escape from the frightful intermittent and more malignant species of fever so easily caught by exposure to the night air and noxious exhalations, especially as they are compelled to drink brackish water, which is considered one of the most injurious beverages possible. I might be asked what I have to do with a medical question here, but its bearing on the working of mines is evidently of importance. I visited Follonica, a little manufacturing village not many miles from Campiglia, in the middle of June, and arrived in time to see the operations, for the S. Giovanni, as the 15th of June is known in Italy, is the signal for all work to be suspended until the beginning of November. If a man exerts himself much, and perspires profusely, he is liable to catch these fevers, which linger about him for a year or two, notwithstanding the extensive employment of quinine by the medical men. The latter informed me that there is less danger for a person riding in a conveyance than for one on foot, who has to exert himself much, but I can testify to the offensive effluvia arising in the marshy ground in spite of the large dykes; for, being obliged to be out late one night, it was very evident to the senses. A poor widow, with whom I conversed on the road, told me a sad tale of the loss of one after another of her family, husband and sons, by fever, and how she was left alone; and a carter who was taking a load of straw from the Maremme to Pisa, told me that in merely passing through Follonica the night before he had caught the fever, and was so weak that he could not sit upright. Nor are these by any means exceptional cases; in fact there is a hospital at Campiglia, where such patients are particularly provided for. To secure a healthy spot for a mine or any industrial establishment in this district, is, therefore, an object of the highest moment, as it permits of the enterprise being carried on so many months longer every

* See chapter VIII.—Lead.

year. The inhabitants of Follonica and other low parts of the Maremme periodically leave their villages, where only a few persons remain behind in charge of the houses, with such as are too poor to remove.

After descending the shaft at the mine of Temperino a few hundred feet, we arrive at the workings; we then enter the *Galleria Fortunata*, a large chamber, 44 yards high, communicating with ancient Etruscan excavations, which lie, however, chiefly at a higher level, having been commenced from the surface at a distance of 220 yards from the present shaft. Further on is an excavation called the *Grande Cava*. These are no longer accessible from above by the original openings, without risking oneself by descending with ropes and other appliances, but in approaching them underground by the modern workings they may be seen to great advantage, and serve very nicely to exhibit the ancient method of mining. Greatly was I delighted to see the grand and almost stupendous proportions of the cavities whence the copper pyrites has been procured, the large vaulted chambers assuming the dimensions of lofty natural caverns, wholly dissimilar to anything of the kind in this country; they frequently attain as much as 15 to 20 yards in height and breadth, and were excavated in hard, fibrous, crystallized amphibole, composed of interlaced fasciculi of crystals, whose axes are placed in different directions between which lie concealed detached pieces or flattened veins of poor copper pyrites. Disseminated through so great a quantity of rock, the ore, as taken from the mine, only yields 3 per cent. of copper. As large masses of amphibole are so intimately associated with the copper pyrites, they have to be entirely worked out as long as the amount of ore is remunerative, which produces the remarkable chambers spoken of, rarely equalled by any artificial excavations.

Below this are two other galleries; in the first are seen ancient works with masses of rubbish, placed aside by the Etruscans, which in process of time have become indurated into a species of breccia by the percolation of ferruginous waters, resulting from the decomposition of the yenite, and perhaps even the amphibole, as I have seen that rock in Tuscany, under certain circumstances, perfectly friable. I found this breccia in places so hard as to need a smart blow with the hammer to detach the original fragments from the paste in which they are imbedded; and in one part I discovered in it a regular little vein of crysocolla about an inch wide. I was much interested in finding snow-white arragonite in the face of one of the old workings; it was not imbedded in the rock, but evidently at the surface, from which it stood out in some measure. I think its formation easily explained by supposing that the atmospheric action on the rock had produced oxidation of the pyrites, and consequently an elevated temperature and that in the presence of carbonic acid some decomposed amphibole had furnished the lime.

At this part of the mine the marks made by Etruscan pickaxes may still be seen, and in the dim light of the oil lamp suspended to the miner's button-hole, and which has very much the form of the Etruscan lamps, a little poetical embellishment will picture out the scene which must have presented itself in this little nook in the rock, when the world had made some 2,500 revolutions less round the sun than at present, or possibly before Æneas set foot on the shores of Lavinia; for such is the fabled antiquity of the polished inhabitants of Etruria.

Close by is a little Etruscan communicating gallery so narrow in places as scarcely to admit of a man creeping along. Though the difficulty of working this hard rock was such as to have made the ancients careful in going through poor ground, they deserve much praise for the skill which they have evinced in their extensive grotto workings, where the ore was richer, for such a fibrous rock presents almost insuperable difficulties without the aid of gunpowder, from the paucity of joints, flows, or cleavage planes, such as in one form or another are common to all stratified and metamorphic rocks.

In one spot above the gallery a considerable quantity of soft ore has been found in nodules, varying in size from an ounce or two in weight upwards: this mineral is subjected to careful hand-picking.

Assays of ores, as raised from the shaft, give

,,	copper.....	3·0 per cent.
,,	broken and hand-picked.....	4·5 ,,
,,	small, washed by machinery.....	5·0 ,,
,,	rich, hand-picked.	15·0 ,,

Some parts of the mine produce a large quantity of "black jack," in others I observed very perfect crystals of dark blende; they are not employed.

The ores were smelted here along with those from Rocca Tederighi, which belongs to the same company. The works have been lying idle since 1859.

At the end of two cross-galleries, white metamorphic Liassic marble has been cut through; it has the appearance of being still stratified, an interesting point, since at Carrara it is almost impossible to detect any stratification, the mass being divided by fresh cleavage planes. In one part of the gallery the marble lies nearly horizontally; immediately afterwards it is seen to rise towards the west, and become almost vertical, so that not only have we evidence of the posterior date of the dyke of amphibole, but of its being the cause of the conversion of the lime-

stone into marble, the quality of which is, probably, somewhat analogous to the ravaccione from Carrara. Several quarries have been made in the neighbourhood for its extraction.

All along the hill side, adjoining the irregular ancient workings, are incredible quantities of copper slag (*loppe*), in small pieces, which, for many reasons, appear to be unanimously considered, both by scientific men and common report, to be Etruscan. I was shown a little pottery lamp, found some time before in the *débris*, but, not being an antiquarian, I am unable to pronounce whether it is Etruscan or Roman.

M. Blanchard, late engineer of the mine, who has analysed these slags, gave me the following :—

Copper, 1·0 to 3·0 ; mean, 2·0 per cent.

I brought away some specimens of the slag for analysis, which, on being broken open, presented small fragments of charcoal ; I found certain pieces to contain no less than 6·5 per cent. of copper.

Lead slags also occur in the same neighbourhood, particularly at the mine called Cava del Piombo ; in all probability they are of the same antiquity. M. Blanchard told me that they contain :—

Lead, 20 to 40 ; mean,	25.	per cent.
Silver	0·0015	,,
Silicates	97.	,,

His estimate of the quantity of the Etruscan scoriæ, or refuse, is no less than 50,000 tons, which, provided the above analyses represent a fair average, must contain at least 1,000 tons of copper and lead. Assuming that the loss in smelting amounted to 5 per cwt., it would give 20,000 tons of lead and copper raised from these mines, and allowing a fourth part to be less ancient, 15,000 tons of metal would have been procured from hence by the Etruscans.

C. Copper in Serpentine (Gabbro Verde).

Having already treated of the geological relations and other scientific points connected with the copper mines in the *gabbro* or serpentine without diallage, I will not repeat them here. The *gabbro* frequently contains the richest ores of copper, but principally it would appear at the junction with the *gabbro rosso*, a brick-red metamorphosed schistose rock, produced by the intrusion of the serpentine into the clays and micaceous sandstones, so abundant in Central Italy.

It would not be correct to say that copper ever forms ordinary veins in the serpentine. Its mode of occurrence is altogether peculiar, and has attracted much attention from Pilla, Meneghini, Savi, and others. Outlying indications of ore, which often surprise the discoverer by their richness, are seen close to the surface, just below the soil, but on digging down nothing more in the way of ore may be found for several fathoms, when suddenly fresh masses of hard yellow copper pyrites, and even richer ores, turn up, in lumps more or less rounded and mostly enveloped in *gabbro verde*. The condition of the matrix is fragmentary, and the serpentine nodules often present the appearance of having been subjected to attrition, as in the act of ejection. The success attending the working of such ores may readily be conceived to have been very varied, and until the able researches of the geologists to whom I have alluded, all was mere groping in the dark ; indeed to this day the Cornish serpentine copper districts remain an enigma. In all cases failure must result without the presence of a thorough geologist, whose intelligence is frequently taxed to the utmost. In too many instances the proprietors lose heart after having for a short time conducted their operations in the most timid manner, without sufficient scientific knowledge, and thus the copper ore is said to be poor. The very large capital required at the outset renders the English method of working by companies composed of shareholders the only one likely to yield any returns. It also appears to me that, having once established the main direction of the ore, it might often be preferable not to commence at the outcrop at all, but if possible to drive an adit level at once, at a vertical depth of several hundred feet below,—a mode of procedure which would be frequently facilitated by the rapid slopes of the hills,—and thus by the formation of a tramroad, without any expense for pumping or raising ores by machinery, there would be a great likelihood of coming directly upon rich deposits of ore.

Monte Catini.—The history of the operations at Monte Catini from the earliest period, commenced, abandoned, and resumed a dozen times, would form a most interesting archæological record, and show what a pernicious influence the unsettled state of Italy in the middle ages had on mining.

That Monte Catini was worked many centuries ago is certain, though the fact that one person or another commenced operations there, or formed a company for exploring the hidden riches of the rock is, for the reason I have assigned, no criterion, as far as Italy is concerned, that the mine was opened for the first time. It would now be a difficult task to prove whether the inhabitants of the ancient Etruscan city of Felathri, now Volterra, knew of the rich deposits of ore so near the gates of their fortress ; no historian whose documents have fallen into my hands has even hinted that such was the case ; but we learn that the mine of Monte Catini was worked during the belligerent days of the Italian Republics, and re-opened in 1469 by Bartolommeo di Agostino, a Florentine gold-

smith. *Deliberazione del Consiglio del comune di Volterra, Filza* 32, *quad.* 2, *a. C.* 29. In 1515 the Republic of Florence restored a great portion of the territory which they had acquired from Volterra, but made a clause reserving to themselves the mine of Monte Catini. In 1494, in consequence of a war between the Florentines and the Pisans, Monte Catini mine was abandoned. 240 *scudi* were invested in explorations in 1513, for the purpose of re-opening it; the names of the parties may be sufficiently interesting to transcribe; they were—Giuliano de' Medici, Giovanni Battista Ridolfi, Angelo Serragli, Piero Guicciardini, and Niccolò Pier Capponi.

Cosmo I., in 1562, resumed the operations, which were pushed forward with energy by that sovereign, and new researches made by his son Francis, in 1574. The Grand Duke Francis I. paid a visit to Volterra in 1580, and having been much interested in all that related to mineral industry, authors have handed down to us various incidents which occurred during his stay there; among others, Giachi, in his *Saggio di richerche sopra lo stato antico e moderno di Volterra.*

The Commissary of Volterra, Giovanni Rondinelli, gave Francis a description of the city and its environs, in which, speaking of Monte Catini, he shows his knowledge of the occurrence of masses of copper ore in that locality, in rolled and independent lumps, associated with steatite and serpentine, and asserts that the nodules had been even known to weigh as much as a ton. The adit level, commenced in 1574, was then (1580) nearly 2,000 feet long. Malaspini, in his funeral oration on Francis I., made by order of the Florentine Academy, lays great stress on the prince having been a liberal friend of mines, and states among other things that he gave exit by an adit level to the water which had previously compelled the abandonment of the mine of Monte Catini, and that he afterwards worked the ore. (Targioni Tozzetti, *Viaggi in diverse parti della Toscana*, tom. ii., p. 294.) Some years later I find that Cesalpino (*De Metallibus libri tres;* Rome, 1594) mentions that copper was then obtained in Tuscany from only two places, Monte Catini and the Caldana, where a warm spring flowed directly into the sea. It was rumoured that Monte Catini mine was once more abandoned in 1630, when the plague broke out with fearful violence at Volterra. Whether it attracted the least notice from any one till 1742, a century later, I have not been able to ascertain, but during that year Targioni Tozzetti visited the spot, described by him as Caporciano. That eminent naturalist relates how all was at a standstill and looked the picture of desolation, but he employed workmen, and examined four ancient pits towards the east, so choked up as to be scarcely visible, and two others on the flank of the little eminence on which stood the castle of Gabretto. He mentions that large quantities of slag were to be found near Monte Catini and Miemmo, and that in one or two instances the peasants had come upon masses of smelted copper, which he considers to have been left during the panic which seized the inhabitants in 1630. (Targ. Toz., tom. ii., 293.)

Little was done till 1827, when M. Porte formed a company for opening the mine of Caporciano or Monte Catini, but 10 years passed without very great results, when Messrs. Hall and Sloane entered the field. The success which has repaid their labours (I believe after having been several times tempted to relinquish the undertaking) is such, that this may be safely pronounced one of the finest mines in the world.

Professor Pilla, more that 17 years ago, when the works were far less advanced than they are now, stated it as his opinion, that though the size of the vein at the mine of Ramelsberg, in the Hartz, was larger, the mass of ore at Monte Catini was greater and more compact than was to be seen elsewhere, and pronounces it to be, *par excellence*, "the richest copper mine in Europe."—(*Breve cenni sulle ricchezze minerali della Toscana*, p. 56.) The ore is found in a vein, distinguished by Burat as "contact veins," that is to say, having close relation to the junction of two rocks, and not traversing a single one, as in Cornish and other well-known veins. During the entire history of the mine, down to the time of Messrs. Porte and Co., it appears that only detached masses of ore were known at the surface; but deeper search, prosecuted with most praiseworthy skill and untiring perseverance by the proprietors, and by Sig. Schneider, their able engineer, have, within the last few years, brought to light a considerable part of the vein.

The situation of the mine is very agreeable; it is in the commune of Monte Catini, lying on the southern brow of Monte Massi, overlooking the extensive plain of the Cecina; the precise spot, as mentioned above, is called Caporciano. To see the air of luxury and cleanliness in the group of buildings belonging to the various gentlemen concerned in the administration, the pretty gardens surrounding them, the substantial church erected about a stone's-throw to the east—were in themselves sufficient evidence to my mind of the success with which the undertaking has been prosecuted, and needed no comment from any one; nor was I in any way disappointed on descending the mine.

The predominant rock in the neighbourhood is *gabbro rosso*, which may be advantageously studied along the road-side. It is schistose in places, and very friable; the strata are violently contorted and frequently nearly vertical, rendering it difficult to ob-

yielding on an average 16 to 18 per cent. of metal.

A second series of cupriferous veins consists of diallagic serpentine, steatite, calcareous spar, copper and iron pyrites, the latter often magnetic: their direction has not yet been ascertained. From the multiplicity of the mineral contents, their crystalline condition and somewhat parallel structure, these veins are seen to be entirely distinct from those first described, which they intersect, so that they are evidently of posterior formation.

The deeper portion of the mine has made known the existence of a large dyke of a similar nature to that of Monte Catini, and which, after describing a large curve, cuts the first system of injected veins. Meneghini, however, considers that by proceeding downwards they will be found again.

The principal shaft is 175 metres deep, and provided with a 16-horse steam engine, worked with lignite from Poder Nuovo colliery. With the exception of the lower one the levels are all in communication with this shaft.

The *Società anglo toscana* have lately directed their attention to the mine of LIBBIANO, adjoining that of Caggio: this company has every prospect of eventual success, having secured such an eminent man of science as Prof. Meneghini to direct the operations. The rocks at Libbiano are of various kinds. The sedimentary strata consist of limestone: this is pierced by four different eruptive rocks, viz., diorite, euphotide, serpentine with diallage, and serpentine without diallage. Copper ore has been found in numerous parts of the commune; thus rich outcrops of veins, or indications of copper, showed themselves at a place called La Trossa, at the junction of the torrent of the same name with the Secolo; a shaft was accordingly sunk at a suitable spot, to the depth of 52 feet, when levels were driven for a considerable distance in search of the vein; none, however, could be found. A beautiful copper vein appeared at the surface, on the banks of the Secolo, south of the Poggio Sugharello, in proximity to *gabbro verde*, and in spite of the immense influx of water a shaft was sunk there. Though Prof. Meneghini is confident that copper ore exists at this place at a greater depth, he has dissuaded the proprietors from prosecuting their search any further, not knowing when they might reach the other part of the vein, the rocks being so convulsed at Libbiano that there is no means of theorizing beforehand on the dip of the vein. The ore at the Botro Castagno has proved very favourable for working; a level was driven from the bottom of the *botro* (ravine), in the direction of the vein, which was cut after proceeding 250 feet, and for the next 180 feet numerous other nearly parallel veins were reached; two of these were followed to the right and left by crossed galleries, and worked by "overhand" and "underhand stoping" (*cammini ascendenti e descendenti*).

A friend of mine, having assayed the ores from Libbiano, kindly placed the following at my disposal:—

	Copper.
Botro Castagno; vein running east and west, dipping north, copper pyrites containing	21·0 per cent.
Ditto ditto ditto	19·8 „
North and south vein, intersecting the former, hard copper pyrites	13·8 „

A specimen of quartz with a small quantity of copper ore, from several spots in the serpentine, yielded, per ton, 6 dwts. 12 grs. of gold; but, what appears to me to be more remarkable, an analysis of the *gabbro* itself is stated to have yielded, per ton, silver, 1 oz. 17 dwts.; gold, 9 grs.

The presence of minute and scarcely utilizable quantities of gold in Tuscany and Piedmont is not confined to lead and copper ores. A manganese ore from Rochetta (*Genoa*), furnished 3 dwts. 6 grs. of gold per ton of ore, and the magnetic iron of Stazzema (*Lucca*), has given silver 2 oz. 16 dwts.; gold 6 dwts. 12 grs. per ton of ore.

I have also before me the assay of some auriferous manganese ore from Beverino, near la Spezia, on the former confines of Piedmont and Modena, containing 31 per cent. of copper, and producing per ton of ore, silver, 13 oz.; gold, 10 dwts. A ferruginous gozzan, from Colle Palestro (*Modena*), gave by assay, 1·25 per cent. of copper, yielding 13 oz. of silver per ton. Yellow pyrites, with manganese in quartz, as broken, furnished 8 per cent. of copper. The amount of precious metal was, silver 2 oz. 18 dwts.; gold 13 dwts. per ton.

At QUERCETO mine, near Libbiano (*Pisa*), Marquis Ginori-Lisci, the manufacturer of the celebrated porcelain at Florence, has obtained nodules of copper ore of excellent quality in the serpentine, and which promise to lead to fortunate results. The vein runs E. and W.

The *Società mineraria montajonese* on their part, have been sinking a shaft near MONTAJONE (*Sienna*), from whence I have seen capital ore. A lump weighing 6½ cwt., chiefly consisting of grey copper ore, was found in this mine at the depth of 120 feet, but the deposit is very irregular and the vein has not yet been discovered. I might refer to the experimental mines of SAN GIMIGNANO (*Sienna*). I have also seen native copper in euphotide from Pari, near Monte Amiata (*Grosseto*).

MONTE CASTELLI Mine (*Sienna*) belongs to the same gentlemen who own Monte Catini, but has not yet been properly studied. It occurs in euphotide. The Grand Duke Francis

commenced an adit level here in 1585, and worked the mine up to the time of his death, two years after, when it was abandoned.

At Riparbella Mine, near Castellina Marittima (*Pisa*), the copper ore is associated with *gabbro rosso* and pthanite on the hanging wall, and diallagic serpentine on the foot wall. The direction of the vein is N. 35° W. to S. 35° E., the dip 45° N.E.

At Montauto, near Arezzo, at the foot of the Appenines, copper ore has been long known to exist in the serpentine, but has never been the source of extensive explorations.

Impruneta is seven or eight miles south of Florence, the ore is there accompanied by diorite, euphotide, and diallagic serpentine. The researches were begun in 1850, by the *Società mineraria fiorentina*. The same company obtained from Castagno in Val d'Elsa, in quite a different part of Tuscany, yellow and purple copper ore and blende, from veins in proximity to *gabbro rosso* and in connection with the serpentine.

At Miemo, the *Società della Faggeta* commenced working in 1846; in 1849 they had already extracted 63,000 Tuscan lbs. of purple copper ore and copper pyrites. (Savi; *Rapporto sull' Esposizione di Firenze dell'* 1850, p. 55.)

Prince Poniatowski possesses a mine at Terriccio, near Castellina Marittima. Prof. Pilla mentions that, some years ago, indications of copper ores were found in the altered *alberese*, in the Valle di Gonnelino, at Terriccio, in proximity to serpentine. After much digging, no vein was discovered, but what was for a long time considered to be the head of a vein proved to be a wonderful mass of copper pyrites, which yielded no less than $16\frac{3}{4}$ tons of ore, and hidden at no great depth. Although the entire mass was not then removed (1844), I believe that nothing has been done there since.

Liguria abounds with serpentine eruptions accompanied by numerous copper veins, which might be turned to account if a careful survey were made. Sig. Perazzi has lately paid a great deal of attention to the copper deposits of Liguria, where seven copper mines have been conceded by the Government since 1857, when they were for the first time thought of. That engineer remarks that the copper ore of Liguria is more concentrated where the serpentine is compact than when it is of a schistose nature; purple copper ore is found in lateral veins. Quartz never occurs in the serpentine but only in the euphotide. The copper veins in the calcareous serpentine are often accompanied by blende and crystalline minerals, and assume somewhat the character of veins in sedimentary schistose rocks.

La Francesca mine at Bonasola, 2 miles from Levanto (*Genoa*), is made in euphotide which traverses the diallagic serpentine. Numerous quartzose veins are met with in the euphotide, having a direction from S.S.W. to N.N.E. and an inclination of 65° E. The copper pyrites is richest in the immediate neighbourhood of the quartz veins, the outer part of which, adjacent to the serpentine, contains the largest proportion of ore.

Close to La Francesca is the mine of Rossora, but there has been little done there as yet. Sig. Perazzi considers that the mine of Frassonide, at Pignone, near Spezia (*Genoa*), has much analogy with that of Monte Castelli (*Sienna*); both are in the euphotide.

There is, I believe, only one copper mine in Central Italy, east of the Appenines, that of Bisano (*Bologna*), recently commenced by the *Società mineralogica bolognese*, a mining company lately established at Bologna; not that these mountains do not contain rich mineral deposits, but that, having been up to 1859 under a feeble government, there was no inducement for entering into mining speculation.

In the face of all these difficulties this company, in 1849, obtained permission from the Papal Minister of Finances to commence working at Bisano, in the Appenines, about midway between Bologna and Florence, and a few miles east of the road. The spot chosen for sinking the shaft is on the right bank of the Idice, a torrent flowing through Bisano, and where some fine specimens of ore had been found during the previous year in the serpentine.

The rocks in this neighbourhood are Tertiary clays, known as *argille scagliose*, belonging to the Eocene formation, and resting on Cretaceous *alberese* limestones. These have been much dislocated and convulsed by eruptions of the two kinds of serpentine I have described, and by diorite and euphotide, which are met with in every direction, the newer serpentine containing indications of copper ore in several places. Levels have been made at the depth of 30 and 76 metres for the purpose of finding the vein. Prof. Meneghini, the director, has succeeded in discovering two parallel veins running N.W. and S.E. The greater part of the levels are driven through indurated clays, which can be worked with pickaxes. In the lower level large masses of *alberese* limestones are found in the steatitic clay, evidently brought up with the serpentine and broken off by the violence of the eruption. A nodular mass of copper ore, of many feet in diameter, was also found inclosed in the soft steatitic clay, but without any connection with the principal deposit or vein. Altogether about four tons of ore have been sent off to Liverpool to be smelted, chiefly excellent purple and yellow copper ores, and some grey copper, very similar to what is found at Monte Catini.

The same company have been making researches at several places in the neighbour-

hood, where copper ore was found in the serpentine at the surface, as at Ferrarina, Pianelle, Fontanelle, and Sassonero. At the latter place a ton of small nodules of fine yellow copper pyrites has been extracted, but the operations have been suspended on account of the quantity of inflammable gases evolved from the decomposing organic matter existing in the Tertiary clays, which vitiate the air and render it difficult to continue working without proper means of ventilation. The quality of these ores is such as to demand the prosecution of the researches, which will certainly be useful in leading to the opening up of other mines in the Emilia.

Of late years the importation of copper ore into England from Tuscany has become an important item, and is rapidly on the increase, as may be seen by the Custom-house returns:—

COPPER ORE IMPORTED FROM TUSCANY.

Years.	Tons.	Value.
1853	34	...
1854	414	£5,175
1855	604	9,488
1856	794	8,464
1857	1,127	25,395
1858	1,124	21,307
1859	1,456	26,257
	5,653	£96,086

ANALYSES OF TUSCAN COPPER ORES IN SERPENTINE BY PROFESSOR BECHI.

	CHALCOSINE, $Cu\ S^2$.						CHALCOPYRITES, $Cu\ S^2 + Fe^2\ S^3$.			
	Monte Catini (*Pisa*).	Monte Catini (*Pisa*).	Botro alle Donne, Monte Vaso (*Pisa*).	Campillore, Monte Vaso (*Pisa*).	Montajone (*Sienna*).	Montajone, with Chalcopyrites (*Sienna*).	Castellina Marittima (*Pisa*.)	Terriccio (*Pisa*.)	Monte Catini (*Pisa*).	Riparbella (*Pisa*).
Copper.....	76·54	63·864	58·500	57·785	31·437	40·892	27·540	15·960	32·788	27·540
Iron	1·75	2·426	1·450	1·333	8·856	15·828	38·800	38·384	29·750	38·832
Oxide of Iron.	0·00	15·750	24·125	25·000	0·000	0·000	0·000	0·000	0·000	0·000
Gangue.....	0·00	0·000	0·125	0·000	42·112	17·935	3·450	4·250	0·863	3·250
Sulphur	20·50	17·631	15·734	15·480	15·977	24·525	30·072	41·306	36·155	30·092
Total.....	98·79	99·671	99·934	99·598	98·389	99·180	99·862	100·000	99·556	99·714

	IN SERPENTINE.								IN SEDIMENTARY ROCKS.			
	BORNITE.								CHALCOPYRITES.			
	Monte Catini (*Pisa*).	Monte Catini (*Pisa*).	Monte Catini (*Pisa*).	Miemo (*Pisa*).	Terriccio (*Pisa*).	Castagno (*Pisa*).	Roccs Sillano (*Sienna*).	Impruneta (*Florence*).	Monte Castelli (*Sienna*).	Capanne Vecchie (*Grosseto*).	Capanne Vecchie (*Grosseto*).	Val Castrucci (*Grosseto*).	Campiglia (*Grosseto*).
Copper.....	55,880	59·472	59·672	60·160	60·007	52·288	46·700	46·300	58·276	45·130	18·008	34·091	31·30
Iron	18,028	13·868	13·868	15·088	15·889	18·192	13·700	15·600	12·134	11·125	43·336	30·292	34·67
Oxide of Iron.	0·000	1·500	0·000	0·000	0·000	0·000	0·000	0·000	0·000	00·000	0·000	0·000	0·00
Gangue.....	0·000	0·750	2·687	0·000	0·000	4·748	18·350	16·500	7·560	25·750	8·624	0·000	0·00
Sulphur	24,926	23·363	23·415	23·983	24·700	24·108	20·015	21·044	22·030	18·088	30·348	35·617	34·03
Total.....	98·834	98·953	99·642	92·231	100,595	99·336	98·765	99.444	100·000	100·093	100·316	100·000	100·000

CHAPTER VIII.

LEAD.

LEAD has been worked from time immemorial in Tuscany. Antonio Filippo Giachi, a chronicler of the last century, mentions among the antiquities of the museum of Volterra certain sheets of lead with Etruscan inscriptions, of which Gori (*Istoria litteraria dell' Italia*, 1784) has given an account, though he considered them worthy of being better illustrated, ranking them, after the *Tavole Eugubine*, among the most remarkable antiquities of the kind. (Giachi ; *Saggio di ricerche sopra lo stato antico e moderno di Volterra*, 1786, p. 199.) I have only seen one or two specimens of Etruscan leaden antiquities,

though I procured at Volterra an ancient casting in lead, said to be Etruscan, and apparently intended to represent a lizard; but the fact that that people had a silver coinage at Pupluna, or Populonia, renders it highly probable that they not only worked the lead, but were able to cupel it, in order to purify the silver. The art of cupellation was then known, a beautiful allusion being made to it by the prophet Jeremiah as practised in his day in Palestine (Jer. vi., v. 29, 30), and the silver of Etruria could only be obtained commercially from lead ores, unless brought from distant countries, which is improbable. Cesaretti publishes an historical document of the 13th century, incidentally alluding to the silver (argentiferous lead) mines in Val Bujo and elsewhere, in the territory of Massa Marittima. (*Memorie sacre e profane dell' antica diocese di Populonia.*) Zaccheria Zacchio, a writer of the 16th century, mentions that in his visit to Populonia he observed a large quantity of slag (*loppe*), which, on being pounded and put into a crucible, yielded silver. (Ughelli; *Ital. Sacræ*, tom. iii., p. 710, 712, 717.) It is not positive whether these slags are Etruscan, or whether the Massetani smelted their lead there in the Middle Ages.

Montieri.—Very considerable quantities of ancient lead slag are found round the Argenteria at Montieri, near Chiusdino (*Sienna*); M. Blanchard, having analysed some of them, kindly gave me the following results of his experiments:—

Lead	4·000
Silver	0·002
Silicates	95·998
	100·000

If it could be proved that this is a fair sample of the entire quantity, it might be worth while to cupel the silver.

The records relating to Montieri go back to the 9th century; its frequent mention in historical documents, in which special notice is made of the "silver" (argentiferous galena) mines, about which I shall quote numerous passages, would lead one to the conclusion that they must then have been very productive. Andrea Baccio (*De Thermis*, p. 214) quotes an author who asserts that a Frenchman discovered some silver mines in 1180 "*in Agro Montis Æris*," which he and his successors worked for many years, and that there were vast caverns and galleries penetrating for a considerable distance into the mountain. Pietro Gallari, while hunting in the woods of Montieri, at the commencement of the 13th century, found a stone the colour of silver, and carrying it to Sienna, for the purpose of having it analysed, it proved to be very rich argentiferous lead ore. He accordingly returned to Montieri, and under pretext of purchasing pasture lands bought the ground for 5 lbs. weight of silver, and having opened a mine he obtained large profits from it. (Giugurta Tommasi; *Historia di Siena*, 1625.) In 1137 the Bishop of Volterra exchanged half the mine of Montieri with the Bishop and people of Sienna for some other property; and in 1151 the people of Montieri swore to preserve half the town, castle, and mine of Montieri to the Siennese, except in case of war with the bishops of Volterra, when they would remain neutral. The mines must have soon become extensive, for Pagnini (*Della Decima Moneta e Mercatura dei Fiorentini*), says that the archives of the bishops of Volterra specify purchases and sales made in that city in 1169, "*boni argenti ad marcum Monterii*," with good silver of the weight employed at Montieri, and again in 1195, *lealis argenti ad pondus di Monteli*, of standard silver, of the weight employed at Montieri (Nardi; *Considerazioni economiche in cui trovossi in Toscana l'Industria mineralogica durante il Medio Evo*, p. 18.)

Not long after this the Republic of Massa Marittima put in a claim for half the mine of Montieri, stating that the Emperor Frederick Barbarossa had conferred it on them in 1160, in recompense for services the Massetani had rendered him. On the other hand the Volterrani alleged their ancient right over Montieri, given them by the Marquis Adalbert, in the 9th century; while the Siennese Republic grounded their claim on the gift to them, by Barbarossa, of half his jurisdiction over the mine, under date 1180: thus continued quarrels about this property. In 1181, Hugo, Bishop of Volterra, gave a quarter of the *castello di Montieri* and of the mine to the Siennese Republic, and received in payment 330 *lire*. His successor, disapproving of this arrangement, would not rest till he had obtained a fresh diploma from Barbarossa, in 1188, by which, among other things, he was re-established in possession of the mine. The pertinacious Siennese, although their adversary held such high ecclesiastical rank, brought their claim before the Court of Rome, but lost their cause, the Bishop of Florence, who was appointed judge, naturally giving a verdict in favour of a member of his own bench. The matter was not so easily calmed down, and it was only in 1214 that an accommodation was made, by which the bishops of Volterra agreed to pay the Siennese Republic the annual sum of 215 *lire* for the town and mine of Montieri. About this time (1193) large quantities of silver from Montieri were taken to Sienna, where luxury became the order of the day, and the citizens began to make the numerous beautiful fountains still to be seen in that city. (Tommasi; *Historia di Siena*, *parte* 1, p. 170.)

In 1246, a natural son of the Emperor Frederick II., Frederick, King of Antioch

and vicar-general of Tuscany, let out the silver mine of Montieri to several trading companies at Sienna. After the death of the Emperor, in order to recover the mines, the bishop of Volterra was obliged, in 1252, to contract a loan of 6,000 silver marks with the Compagnia de' Buonsignori of Sienna, allowing them to hold possession of the mine on condition of rendering an account to him of the proceeds every six months. (Porte; *Raggionamento intorno alla riattivazione che si propone d'intrapendere di alcune miniere, in Toscana*, p. 27.)

Bentivegni di Ugolino, a Florentine merchant, rented the Montieri mines from the Emperor Frederick II. for a couple of years, from 1243 to 1245, and obtained the right of coining money from them, for which he paid 11,000 *lire picciole pisane*, or 11,000 golden florins; he, however, gave up the privilege of coining to the citizens of San Gimignano for 1,000 silver marcs, equal to 7,500 golden florins. (Coppi; *Annali di San Gimignano*, liber ii., p. 106.)

It may here be appropriately mentioned that previous to the year 1200, there were numerous mints in Tuscany; the Tuscan silver coinage abounded throughout Europe. The Florentines had their own silver money coined at Volterra. Nardi (*Op. cit.*, p. 4) states that from the year 1200 to 1400 the Tuscans were the masters or lessees of the principal mints in France, Germany, England, and the East, proving their skill in the art of coining.

In 1258, the Bishop of Volterra gave permission to certain persons to farm the privilege of coining money at Montieri for eight years. About this time, in 1287, the price of silver fell considerably, and the miners of Montieri began to cry out against the exorbitant sums they were obliged to pay the bishops of Voltera, namely, one basket of ore for every four extracted, and offered to give only one in eight. (Porte; *Op. cit.*, p. 28.) During the year 1327 the Siennese laid hands on half the mine, because the stipulated annual sum was in arrears; with the silver which they took to Sienna they displayed so much magnificence that the bishop perceived, too late, the error he had committed, for although the Republic of Massa about this time sent troops to lay siege to Montieri, which they took, they were unable to retain it, and thus the town returned to the Siennese Republic, who held it down to 1554, when the power fell by the victorious arms of Cosmo I., and was incorporated into the Grand Duchy of Tuscany.—(Targioni; tom. iii., p. 30.) (Repetti; *Dizionario Storico della Toscana*, tom. i., p. 193; and tom. iii., p. 573).

The *Archivio Mediceo* mentions that in 1584 Cosmo commenced re-working an ancient mine at Montieri, called *Cava della Treja*. I have been unable to glean any particulars regarding the Montieri mines since that time, in fact it is doubtful if any operations have been carried on there for the last two centuries.

The whole hill-side of the Cornate di Gerfalco, north of Montieri, is strewed with small fragments of limestone thrown out of ancient pits. I traced them for half a mile in a direct line, and nearly on the same level. Apparently there were not any deep workings; on the contrary, the rock has been only "scratched" at the surface, the little cavities following each other at the distance of a few fathoms. It would no doubt yield a good return to anyone disposed to go over the ground systematically and lay open the bed of lead. Sulphate of baryta and fluor spar are the accompanying minerals, the latter quite white or colourless; also cupriferous arragonite, constituting the new mineral Mossotite, is found in some of the cavities. I succeeded in picking up some pieces of rubbish containing traces of green carbonate of copper. As at Montieri, these beds or veins have been long neglected.

Regarding the lead mines of the Grossetano in the Maremme, we learn that Ugolino Scolare Visconti submitted to the Siennese Republic in 1147, taking the necessary oaths of allegiance. He subsequently gave over to the consuls and council of the Republic the fourth part of his share in the mines of lead, gold, silver, or whatever other metal might be worked within the *castello* (fortified village), and district of Batignano and Monte Orsajo, within certain boundaries, which he fixed at Roselle (an Etruscan city now completely destroyed), Monte Orsajo, Torri, and thence as far as the Ombrone, giving the Siennese the right of digging at any of the said places, excepting within the actual precincts of the castle of Batignano. Visconti then made the people of Batignano and Torri swear to the observance of the agreement. The result, favourable as these terms might seem to the Siennese, turned out otherwise; in fact, the mines, no longer worked by the Counts of Batignano, were neglected by the Republic, who soon found other more stirring occupations of a military character. (Tommasi; *Historia di Siena*, lib. iii., p. 142.)

Galena is found at the ancient mine of Cava del Piombo, near Campiglia (*Grosseto*), in rusty-green amphibole, associated with zinc. The ores are divided into three kinds, yielding 15, 27, and 42 per cent. of lead, which contains on an average 0·0015 of silver. I consider it more than probable that the Etruscans of Populonia obtained their lead and silver from this mine. The ancient levels at Cava del Piombo contain the beautiful mineral called Buratite, in honour of Burat, the former director of one of the neighbouring mines. This mineral has been formed since the works were abandoned.

A lead mine is now in activity at Castel-

LACCIA (*Grosseto*), (*Società metallo-tecnica*), four or five miles from Massa Marittima, from whence a road has been made. I obtained from thence both galena and fine resinous-looking blende. Seven new cupolas (*forni a manica*) and a cupel (*forno a cupello*) have lately been erected at Castellaccia. These have been in operation three years. The blast is supplied by a cylinder, moved by a 14-horse power horizontal high-pressure steam engine, manufactured at Lincoln.

The metallurgical operations are very simple. The ore, after preliminary preparation by stamping, and dressing with jigging machines, percussion tables and round buddles, roasted, and placed in the cupola with charcoal, and produces a "matt" (*metallina di prima fusione*) and metallic lead. The matt is then roasted, to facilitate oxidation, and placed for two hours in a cupola with charcoal, by which process more lead and a second richer matt or *metallina* is extracted. All the lead is cupelled. The ores are dressed on the spot, a stream of water flowing through the deep valley at the foot of the slope on which the furnaces are built. The fuel employed in the smelting processes is charcoal.

We will now pass to the extreme north-west angle of Tuscany, formerly called the Versiglia, embracing the country around Seravezza, Camajore, and Pietrasanta, with all the valleys and mountains, as far as the recent frontiers of Tuscany and Modena. It embraces the mineral districts in which I have noticed the occurrence of so many splendid beds of marble, which early attracted the attention of the inhabitants.

The resources of the Versiglia were held in great estimation in the time of the Romans, but the Senate, fearing that the people would proceed too rapidly and eagerly to work, and thus exhaust the minerals, passed a general decree laying restrictions on the working of mines in Italy. Their motive was, doubtless, a wise policy for those times, since the ancients seldom proceeded to great depths, and thus a locality soon became unproductive; while on the other hand these restrictions taught and, in some measure, compelled the citizens to develop the resources of their distant colonial possessions. This spirit of colonial enterprise, now so peculiarly the trait of the British nation, was one of the reasons why Rome rose to the first place among the empires of the world; and may not Italy, appreciating her present position, and following the same example of extended commercial intercourse with foreign nations, hope for similar grandeur in the 19th century?

BOTTINO MINE.—Two miles east of Seravezza (*Lucca*), at a place called Gallena, on the right bank of the Vezza, is situated the lead mine of Bottino, lately belonging to the *Società metallurgica livornese*, but now to the *Compagnia anonima del Bottino*. It has long been of great importance; the ore is rich in silver, and sometimes contains antimony. The veins and beds occur in Palæozoic quartzose steachists, nearly parallel to the stratification, or more probably cleavage planes of the rock. The direction of the veins is N.N.W. and S.S.E. They fill the fissures which have been evidently produced by the eruptive rocks in the act of upheaving these mountains, and are of very different origin to the dykes of magnetic iron at Stazzema, a few miles distant. The vein, varying from four to ten feet in width, is not entirely metalliferous; the band which contains the ore is from four inches to a foot wide, and is said to be perfectly continuous. It has been worked to a depth of at least 125 metres.

In the Middle Ages Bottino belonged to the Signori di Corvaja and Vallechia, who worked the ore on their own account; it subsequently passed into the hands of the Grand Duke of Tuscany, Cosmo I., in 1540.

On the southern slope of Monte Gabberi, south of Bottino, with which they are no doubt geologically connected, are the mines of Argentiera, or Sta. Anna, in the VAL DI CASTELLO, belonging to Cav. Hähner. The earliest account of them which I have been able to meet with is that by Muratori, who alludes to their being worked in 1203. Cosmo I. re-opened them likewise, and they were worked, along with Bottino, by his two immediate successors, Francis I. and Ferdinand I.

The Table (see next page) shows the produce of the lead mines of the Monte dell' Argentiera and the vicinity, in their most flourishing days, under the first three Grand Dukes of Tuscany.

Much difficulty was experienced by the princes in obtaining the silver when extracted from these ores. Giezzel, a German engineer, was indeed brought over in 1542 to conduct the business, but still strong suspicions were entertained that a large proportion of the precious metal was systematically stolen, and Ferdinand I., acting on this supposition, in which he was doubtless perfectly correct, resolved to have nothing more to do with the mines, giving them over to the miners to work on their own account. These very soon obtained a very different result, suddenly becoming possessed of great riches; but such a state of things could not continue long, and as the Grand Duke was unable to obtain justice he suddenly suspended all operations in 1593. (Fedele; *Saggio storico ecc., dell' antica e moderna Versiglia*, p. 296.)

Coming down to our own times, Argentiera was re-opened for several years, but eventually closed in 1851. Much mystery and secresy is maintained respecting these mines. I was assured that new veins of considerable dimensions had been lately discovered in the Galleria Sta. Barbara, though they have not yet been turned to account. A very complex

and valuable grey copper, from Angina, Val di Castello, analysed by Kersten, gave:—

Iron	1·89
Copper	35·80
Antimony	27·47
Silver	0·33
Zinc	6·05
Mercury	2·70
Sulphur	24·00
	98·24

An assay of iron ore from Val di Castello gave per ton :—

	oz.	dwt.	gr.
Silver	6	4	10
Gold	0	10	0

The silver of Val di Castello used to be sent to Genoa, and realized 140 *paoli* per lb., or 6s. 1d. per avoirdupois ounce, because of the small proportion of gold which it contained. The lead was sold at Leghorn for £1 per cwt.

Bottino was re-opened in 1830 : for twelve years the result was rather unsatisfactory, but since 1842 the produce has been very considerable. It is the only mine in the Versiglia which has been uninterruptedly in operation until the present time.

In 1849 the produce was—

	Tons.	Cwt.
Silver	0	7
Lead	53	10
Litharge	6	0

The dividends were £880.

I was told that the lead contained 0·004 of silver, which is separated by cupellation, and was, until lately, sold at the mint at Florence

PRODUCE OF THE MINES OF MONTE DELL' ARGENTIERA.

YEARS.	QUANTITY OF WASHED MINERAL SMELTED.	METAL OBTAINED FROM PRECEDING ORES:			EXPENSE.
		PIG LEAD. Before cupellation.	SOFT LEAD. After cupellation.	SILVER.	
	tons. cwt. lbs.	tons. cwt. lbs.	tons. cwt. lbs.	lbs. avoir.	£
1565	28 11 59	13 17 98	5 9 56	137·0	933
1568	26 1 44	15 14 87	6 17 35	140·3	871
1572	18 0 108	13 9 31	3 4 52	123·6	910
1573	13 4 4	9 13 87	3 5 17	86·1	983
1574	13 14 7	10 19 36	4 8 75	155·8	1,090
1581	15 10 93	9 16 10	3 5 62	141·5	1,331
1585	14 0 81	7 10 41	3 3 90	150·4	943
1587	23 14 67	5 19 49	1 15 88	63·3	1,037
1589	47 6 59	8 9 48	2 0 16	142·1	1,358
1590	41 3 59	5 0 38	1 15 91	78·2	812
1591	54 5 63	8 0 69	1 11 108	128·1	744
1592 18th Sept.	24 16 0	3 2 30	1 1 50	46·7	447
	320 9 84	109 13 64	37 19 68	1393·1	£11,459

—(Repetti; *Dizionario istorico della Toscana.* Tom. I., p. 130.)

at the rate of 130 to 132 *paoli* the Tuscan pound, or 4s. 3½d. to 4s. 4d. per avoirdupois ounce; while the price of the lead at Leghorn varies from 30 to 33 *paoli* the *cento* (£1 2s. per cwt.). Quite recently the silver from Bottino has been sent to Paris, where the gold is extracted from it with a certain advantage.

The 60 metre level, called *Galleria della Redola*, is supposed to be have been made in the Middle Ages, but being very narrow and low, it had to be enlarged by the present company before being able to employ it. The *Galleria Paolo* served for the operations up to 1850, but now a shaft, called *Pozzo della Speranza*, has been sunk 65 metres below it, at which depth a fresh adit level is in course of construction, and will probably be completed in the course of four years. About 25,000 tons of ore stuff are raised annually, which, after having been hand-picked and broken, are reduced to 2,500 tons of ore, containing from 8 to 10 per cent. of lead.

The dressing-house is provided with two crushing-cylinders and stamps, set in motion by an hydraulic wheel of 15 horse-power, as are likewise an apparatus for washing the slime, and six jigging-machines: there are also 17 hand-jigging-frames. These bring up the ore to 25 per cent., but it is found convenient not to proceed further, in order to avoid the loss of the silver contained in the pyrites and blende.

The refuse from the jigging-frames is stamped, furnishing coarse sand, which is treated on German tables, medium sand for

the inclined tables, and fine sand washed in the round buddles, About 700 tons of dressed ore, containing 30 per cent. of lead, are produced here annually.

There are 3 German tables.
„ 8 inclined tables.
„ 2 buddles.

The dressed ores are conveyed along an incline plane to the smelting works at the foot of the hill, in sacks holding 100 kilogrammes each. One sack is placed on either side of a saddle-shaped machine, called an *uccellaccio* (literally meaning an ugly bird, on account of its being furnished with a pair of wing-shaped canvas fans, covered with brushwood, which serve as a break to prevent it from descending the incline plane too rapidly). The *uccellacci* run on little toothed wheels, permitting of a certain grasp on the tramroad, which consists of pieces of wood supported on poles, and covered by slender bars of iron in the form of rails.

One man accompanies two machines, carrying 400 kilogrammes, or nearly 7⅞ cwt. of ore. The road is very irregular, following all the sinuosities of the hill side; there are numerous sharp curves, so that the machines frequently stop, and the men are obliged to set them in motion again. On the return journey the men carry their two machines, weighing together ninety pounds on their backs, making use of the sacks as a sort of pad. They are paid 0·35 francs for each journey, of which they generally make four daily, thus earning 1,40 francs. Some men make five, and even six trips, though rarely. The great drawback to this highly interesting means of transport, which was devised by Sig. Vegni, is the expense of repairing the road, as the iron bars get continually torn off by the toothed wheels of the machines, which proceed with jerks from point to point. The total expense of transporting a ton of ore, including the repair of the road thus amounts to 2·50 francs or 2s. The uccellacci have been within the last summer replaced by a regular tramway, 1,200 metres long, which conveys the ores at a fraction of the expense.

The dressed ore is roasted in little furnaces, in shape like a lime kiln, and are then smelted in the cupolas. The charge is added every half-hour, and consists of—

Roasted ore 3/5
Poor slags 2/5
Rich slags and cupel refuse ... 1/5

The fuel employed is light coke from Marseilles and heavy coke from England. The furnaces are tapped twice every twenty-four hours, producing from 450 to 530 lbs. of lead.

The last matts, which contain 4 per cent. of copper, are roasted for two or three weeks in the same furnaces as the ores, after which time a gentle stream of water is admitted at the top of the furnace, by which the sulphates of iron, zinc, and copper are washed out and collected in a reservoir, ready to be precipitated by scrap iron. About two per cent. of copper is recovered by this means; of the rest, one per cent. goes to waste, and one per cent. remains in the matt, and is treated a second time. The cement copper is refined once a year, and produces 14 to 15 cwt. of refined copper.

Every two or three weeks twelve or thirteen tons of lead is cupelled. The litharge is divided into three kinds; black litharge for making hard lead; yellow litharge for making soft lead, and red commercial litharge. The black and yellow litharge is treated several times a year. The silver as it comes from the cupel has a standard of 950 to 985, so that it can at once be made into ingots.

The metallurgical operations are carried on for the eight or nine months when there is sufficient water in the Vezza to move the hydraulic wheels and the turbine which supplies the blast.

The production of Bottino mine of late years has been as follows:—

	1856-7.	1857-8.	1858-9.	1859-60.	1860-1.
	Tons. cwt. lbs.	Tons. cwt. lbs.	Tons. cwt. lbs.	Tons. cwt. lbs.	Tons. cwt. lbs.
Pig lead	239 0 28	303 5 56	273 2 0	172 12 0	129 5 56
Silver	0 17 10	0 25 15	0 23 56	0 17 24	0 10 70
Soft lead	88 6 56	90 11 28	88 2 28	47 1 84	41 8 0
Hard lead	7 17 84	17 15 56	20 8 28	12 9 84	3 12 28
Litharge	36 1 0	52 4 84	43 13 0	27 5 56	21 19 28

NUMBER OF WORKMEN EMPLOYED AT BOTTINO MINE IN 1861.

Underground:—	Francs.
120 Miners, at (per day of 10 hours).	1·35
6 Carpenters	1·35
54 Miners employed in removing ore and rubbish	1·10
6 Smiths	1·50
6 Smiths' labourers	0·70
2 Head miners	1·50
1 Captain (at per month)	84·00
Dressing-house:—	
30 Sorters	1·00
12 Men	1·10

	Francs.
35 Boys	0·50
4 Women	0·56
26 Women	
2 Superintendents	2·00
1 Female superintendent	1·50
At the roasting kilns:—	
6 Men	1·00

At the smelting works:—

No returns.

Bottino produces some rare and interesting minerals, among which I may mention Heteromorphite, or capillary sulphuret of antimony and lead; $2PbS + SbS^3$. It is associated with quartz and bitter spar. I procured some specimens in which the crystals were at least one inch in length, and others of a similar nature from Monte Tambura mine.

Meneghinite, $4PbS + SbS^3$, and Targionite, are peculiar to Bottino.

There are some lead veins on the Alpe di Terinca, near Levigliani, five miles above Seravezza, which have not yet been worked: five parallel veins have already been discovered close to each other, and varying in width from 4 inches to 4 feet at the outcrop, which is near the junction of the limestone with the ancient rocks. An experiment made on 100lbs. of mineral produced 66lbs. of lead, containing 0·0037 of silver and 0·000004 of gold.

Tambura Mine.—Not twelve miles from Massa di Carrara, in the former Duchy of Modena, rises the lofty peak of Monte Tambura. A lead mine has been opened in the limestone strata on its flanks, at a considerable height, but, owing to there being only a wretched horse-road to it, it is almost impossible to reach the place. The ore is massive, and very argentiferous, and found in a vein two or three inches thick.

Anaysis of Lead from the Tambura Mine.

Lead	62·08
Sulphur	9·50
Protoxide of iron	0·50
Silica, free and combined	23·00
Loss	4·92
	100·00

Assays of Lead from the Tambura Mine, Containing per Ton of Ore

	Lead.	Gold.	Silver.
	per cent.	oz. dwt. gr.	oz. dwt.
Sample 1	50·0	1 2 20	0 0
do. 2	50·0	0 6 12	0 0
do. 3	not estimated.	1 9 9	24 10
Upper vein	50·0	0 0 0	45 16
Parallel to last	not estimated.	0 0 13	23 13
2nd vein rather disseminated in Schist	36·0	0 0 13	12 1

Analysis of Tuscan Lead Ores by Professor Bechi, 1850.

	Coarse-grained galena, Bottino.	Fine-grained galena, Bottino.	Galena, Bottino.	Galena, Bottino. (*Lucca.*)	Galena, Val di Castello (*Lucca*).	*Federerz* ($PbS + SbS^3$), Bottino.	*Federerz*, Bottino.	Boulangerite ($3PbS + SbS^3$), Bottino.	Boulangerite, Bottino.	Boulangerite, Bottino.	Jamesonite ($3PbS + 2SbS^3$), Bottino.
Lead	80·700	78·238	78·284	72·440	72·900	47·681	49·311	53·154	55·390	57·421	43·383
Antimony	3·307	4·431	2·452	4·308	5·770	30·186	29·244	26·085	26·740	23·981	32·158
Iron	1·377	1·828	2·811	1·855	1·770	0·255	0·000	0·350	0·230	0·732	0·945
Copper	0·440	Traces.	0·000	4·251	1·110	1·110	2·000	1·242	1·250	1·311	1·244
Silver	0·325	0·485	0·560	0·650	0·720	0·000	0·000	0·000	0·000	0·000	0·000
Zinc	0·024	0·000	0·000	0·000	1·330	1·085	0·211	1·407	0·085	1·003	1·736
Sulphur	12·840	15·245	15·503	16·780	15·620	18·395	19·250	17·994	17·822	17·744	20·432
Total	99·013	100·227	99·610	100·284	99·220	98·712	100·016	100·232	101·517	102·192	99·898

CHAPTER IX.

SILVER.

QUANTITY OF SILVER IN TUSCAN ORES, ANALYSED BY PROF. BECHI, OF FLORENCE.
(*Atti dei Georgofili*, 1856, *Tom. III., Nuova Serie.*)

Nature of Ore.	Locality.	Silver in 1,000 parts of ore.
Copper Pyrites	Capanne Vecchie, Val Castrucci, Accesa, Brenna, Campiglia, Montieri	0·28
Grey copper	Serra Bottini, Boccheggiano, Cugnano, Capo Calamita	0·28
	Gerfalco	8·70
	Montieri, Val di Castello	10·00
Galena	Val Castrucci, Poggio al Montone, Val d'Aspra, Bocchegiano, Accesa, Brenna, Serra Bottini, Montieri (partly)	0·60
	Campiglia	0·32
	Montieri (partly)	0·96
	Val di Castello (very fine grained ore)	6·50
	Bottino (fine grained ore)	5·60
	id. (coarse grained ore)	3·23
Boulangerite	id.	1·90
Jamesonite	id.	1·90
Targionite	Val di Castello	7·20
Fahlerz	id.	4·50
Blende	Campiglia, Accesa, Poggio al Montone.	0·28
Marmatite	Bottino, Val di Castello	2·00
Iron Pyrites	id. id.	0·50

SILVER is only found in Central Italy in combination with other ores; the copper, lead, and zinc ores occurring in sedimentary rocks often contain a considerable quantity of silver, but Bechi has pointed out the curious circumstance that the copper in serpentine is entirely free from that metal.

CHAPTER X.

MERCURY.

AT least four mines of cinnabar exist in Tuscany; only one of them is in operation just now, that of Stiele (*Grosseto*).

The cinnabar mine of SELVENA, near Sta Fiora (*Grosseto*), dates from the 13th century, for mention is made of its being worked in 1272 (Repetti; tom. v., p. 241), and the reader who may desire to know the manner in which the metallic mercury was there separated in the Middle Ages may consult the drawings given by Mercatti (*Metallotheca Vaticana*).

Selvena mine was re-opened in 1849, and is at present the property of Messrs. Sadun and Roselli. The annual production is 3½ tons, which are smelted at the works of Modigliana.

In the same neighbourhood mercury has been procured from PIAN CASTAGNAJO. The researches were commenced in 1846. From 1848 to October, 1849, they yielded about 3 tons of mercury.

Cinnabar also exists at CAPITO, near Capalbio, but is not extracted.

The cinnabar mine at Torre di JANO, near Montajone, 12 miles north of Volterra, belonging to the *Società mineraria fiorentina*, is no longer in operation. It is in soft blueish carboniferous clays and schists, lately discovered by Meneghini, who was the first to

announce the presence of Carboniferous fossils on the Italian continent.

Where a natural section or cutting of the shales is obtainable, they are seen copiously covered with an efflorescence of sulphur, imparting to them a pale yellow colour. The schists are in places sufficiently impregnated with cinnabar to have a red tinge, but I could not see any true vein; possibly the ore may be derived from some vein destroyed by the neighbouring serpentine in the act of eruption, when the vapour of the cinnabar diffused itself through the shales, as being the least solid rock in the locality; the pulverulent aspect of the cinnabar is, to say the least, very diferent from what one would suppose if it were *in situ*.* The ore was worked by galleries driven into the side of the hill. An ancient gallery is reported to have been made near Jano, for the extraction of sulphur alone. Two furnaces served for the continuous distillation of the cinnabar: the ore was classified into four kinds: best ore 20 per cent., picked ore 40 per cent., 2nd quality 11 per cent., 3rd, poor ores 1½ per cent.; they were introduced into cylindrical cast iron retorts somewhat similar to those employed in the manufacture of gas.

The mine of Levigliani, near Seravezza (*Lucca*), is probably very ancient, but some old authors employ the same word to signify a *vein* and a *mine*, which causes a little ambiguity in their description of mineral deposits. The circumstances which brought the mercury of Levigliani into notice are too interesting to be omitted. Cosmo III., as patron of the Grand Ducal printing establishment at Florence, was anxious to publish some ecclesiastical works in black and red, and learning that cinnabar existed near Seravezza, he sent Giuseppe Antonio Torricelli, one of the sculptors of the Imperial and Royal Gallery of *Pietre dure*, to examine the matter for himself, and if possible to re-open the mine, in order to procure a brilliant vermillion ink. In a short time Torricelli, who appears to have been a very intelligent man, returned to the capital with 120 pounds of cinnabar, which he had himself obtained, adding that he had left an immense quantity behind. The Grand Duke was so delighted that, in 1718, he handed over to the printing establishment the right of working the mine for themselves, to aid in defraying the expenses of bringing out the books in black and red, though it was hinted to him that, according to the version of Torricelli, he had been far too liberal. The new proprietors immediately made overtures to Torricelli to return and conduct the operations, but he resolutely refused, and could not be persuaded to go. As an excuse, he proposed another man, but the latter during two summers made a very poor business of it, the expenses exceeding the proceeds. Subsequently a superintendent going there under the royal patronage had no better success. Were it not for positive evidence we might be sceptical as to whether Torricelli ever procured the cinnabar in such large quantities, and in so short a time, but Targioni, about 30 years afterwards, went to the spot and broke off specimens of cinnabar, and was informed by the village priest that he was an eye-witness of the discovery of Torricelli; that, moreover, one day when the latter had sprung a mine, fluid mercury flowed out in such a constant stream for some minutes, that the men, having no more vessels in which to receive it, filled two of their caps with the pure liquid metal. (Targioni Tozzetti; *Viaggi in Toscana*, tom. iv., pp. 120, 129.) So late as 1838 the mine was re-opened, and produced, according to Sig. G. Santini, 2¾ tons of cinnabar annually. In 1853 the great influx of Californian mercury caused it to be definitely abandoned. The cinnabar is very massive, and occurs in minute veins associated with quartz in schistose rocks, at the base of Monte Corchia.

At Ripa, two miles below Seravezza, veins of cinnabar run with a nearly horizontal course, from N.N.E to S.S.W., occasionally 4 or even 9 inches thick; the average does not exceed an inch in thickness; they are situated on the western slope of the hill, which is composed of soft, greasy, whitish, Oolitic steaschists. The cinnabar was discovered in 1841, and in a short time three companies were engaged in extracting it, the *Società Idrargica*, Montemart e Peryer, and Hähner and Co.; previous to the summer of 1845 the two latter had obtained 20 tons of mercury, which was distilled at the mines. (Repetti, *Dizionario Istorico.*) Levels have been prosecuted for some distance into the hill,

Approximate Yield of the Mercury Mines of Ripa, worked by the three companies, as roughly estimated for me by Avv. G. Santini, who is alone responsible for the figures.

Years.	Cinnabar extracted.	Distilled Mercury obtained.	Value of foregoing.	Price per lb. avoird. at Leghorn.
	tons.	tons. cwt. lbs.	£	s. d.
1842	99	2 0 12	666	3 0
1843	199	4 0 30	1,333	3 0
1844	332	6 13 75	2,222	3 0
1845	498	10 0 78	3,333	3 0
1846	664	13 7 40	5,333	3 7
1847	1,329	26 14 83	12,444	4 2
1848	1,329	26 14 83	12,444	4 2
1849	1,329	26 14 80	8,888	3 0
1850	1,329	26 14 80	3,333	1 9
1851	664	13 7 35	2,666	1 9

* It may be here observed that most of the cinnabar is produced from shales and other rocks of the Carboniferous system; thus that of Almaden, in Spain.

with tramroads; the names of these levels are Gallerie Federiga, Santini, Sta Barbara, Enrichetta, Peryer, Montemart, and Sofia. I procured some truly splendid massive lumps at the mines; though the veins are small, the mineral is a fine ruby-red. The matrix is a soft rock, and easily worked; the soapy feel which it presents is somewhat remarkable; it often assumes the appearance of clay, the more so in certain thin beds between the more compact strata, the material from which can be easily moulded in the hand: a small quantity of cinnabar is disseminated through the rock itself.

CHAPTER XI.

ANTIMONY.

The few remaining mines are of less industrial importance. Antimony is found at Pereta, in the Maremme. not far from Grosseto, in long crystals of great beauty, affording some of the finest specimens in the world. I have seen masses of at least a cubic foot, composed of the most splendid crystals of sulphuret of antimony, interlacing each other, procured from a cavity. It exists in nests in the *macigno* sandstone; the ground is soft, and has been decomposed by sulphurous emanations. Pilla states that while some of the masses are too small to work, others have yielded from 17 to 34 tons. The produce in 1844 was 53½ tons; in 1845, 48½ tons, and the total produce down to 1849, 312 tons. Bechi has analysed the antimony ores of Pereta, and published the following results:—

Antimony	78·53
Sulphur	19·47
Peroxide of Iron	1·25
Insoluble residue	0·75
	100·000

The mines of Montauto (*Grosseto*), near the present Papal frontier, were commenced by M. Mejean, in 1844, in blackish clays, resulting from the decomposition of the *macigno*. They produced 43½ tons of ore in 1844, and 168 tons in 1848-9, up to which time the total quantity extracted for five years was 712 tons (Pilla; *Cenne sulle ricchezze minerali della Toscana.*) The mine of Montauto is pretty active. The ore is treated in the smelting works of Messrs. Pate and Son, at Monte Argentario, near Sta Stefano (*Grosseto*). Thanks to the skill of Prof. Bechi, who is the director of the works, the regulus is of a quality to permit it to compete with any in the market: the Jury pronounced it the best in the International Exhibition. About 50 tons are manufactured annually. Sulphide of antimony also exists at Castagneto and Micciano, in the Volterrano, and I have seen good specimens from Selvena, near Sta Fiora, where it has long been known. A farmer at Cipolleri gave me a good piece of antimony ore, which he had procured near his farm, about five miles from Massa Marittima, though no one has yet thought it worth while to pay attention to it. The lump in question is crystallized, and embedded in a hard siliceous matrix, evidently consolidated since the formation of the antimony; it very closely resembles in structure and occurrence the antimony of Prochio, in the island of Elba; therefore, I presume it has been formed in the same manner.

CHAPTER XII.

MANGANESE.

Manganese occurs in several parts of Tuscany. At Monte Nero, south of Leghorn, it is found in connection with serpentine, which is largely developed from thence to Romito; the veins have altered the schistose clays. Savi is of opinion that these manganese veins are due to the deposit of mineral waters, such as the neighbouring slightly manganiferous spring of S. Quirico. In the most ancient sedimentary rocks manganese is likewise found, as at Cappanne Vecchie (*Grosseto*), it has also been recently worked at Torciliana, five miles south-east of Camajore, in the province of Lucca. I cannot say why they have suspended the operations, but it seems that some difficulty was experienced in selling the ores which is not uniformly good: some of it is rather earthy, but other specimens of compact oxide indicate the probable existence of better ore if the explorations were prosecuted. Those who are interested in mineral veins would be well repaid by a visit to this place. Climbing up the steep face of the hill for about half way—probably 1,000

feet—through an oliveyard, we arrive at a bold bluff in which is seen to great advantage the outcrop of the manganese vein. On approaching it on either side, I noticed a marked alteration in the strata by the intrusion of the manganese, and become reddened by the peroxidation of the iron they contained, so that the rock has completely lost its original structure, assuming the appearance of a hard metamorphic substance.

At La Rochetta, near Spezia (*Genoa*), some miles north of Carrara, other manganese veins have been tried. I will endeavour to sketch out the geology of this little-known but highly-important neighbourhood, a general view of the subject being essential. Monte Nero is a precipitous hill, situated about 12 miles north of Spezia, round whose south and west slopes the Magra takes a semi-circular course. At the north is a deep valley, piercing numerous and distinct serpentine eruptions, and passing through La Rochetta. Opposite this hamlet, on the north flank of Monte Nero, are several veins of manganese, of a more or less pure nature, but "scratched" over throughout their length, that is, for perhaps, a kilometere. The schists in which they occur have been metamorphond in a remarkable manner in this vicinity of the serpentines, so as to assume the character of jasper. One bluff of jasper is especially remarkable, and is called "Carrara." It is here that the jaspification has been most perfect, the rock has become eminently friable, and constitutes the pozzuolana earth, while the manganese in other places, instead of keeping separate, unites chemically with the schist, and forms useless silicate. In the schists are frequent thin strata of grey impure limestone, which, in proximity to the veins, are insensibly converted into umber of good quality for painting. Part of the manganese ore is a rich peroxide, suited for glass manufacture, but the greater part, as may be imagined, is too much indurated and too ferruginous to enable it to be used for this purpose.

Two miles south of Borghetto (*Genoa*), the first stage N. of Spezia in going towards Genoa, is a small spur of the hill, on the side of which is seen the outcrop of a manganese vein, of two or three feet in thickness, running on the whole with a nearly horizontal course, but dislocated every few fathoms with minute faults. The ore is so hard that, until lately, it was considered useless, when the director of the Royal Tuscan Iron Foundries experimented on it with a view to find if it could be smelted with advantage in certain proportions with the specular iron ores of Elba. The result has proved highly satisfactory; and in the Exhibition of Florence, in 1861, some fine specimens of iron were shown, having the same fracture and large crystalline facets of *Spiegeleisen*. In consequence of these experiments, great activity prevails here now, and the ore is sent off in very large quantities to Follonica, notwithstanding the heavy price of transport for two miles to Borghetto along the stony bed of a torrent, and from thence to Spezia for 14 miles by road.

At Framura, two miles from Levanto (*Genoa*), richer oxide of manganese has been lately worked by open cast pits. As at Rochetta, the manganese ore is accompanied by rocks, which it has in places penetrated in a remarkable manner, producing fine brown umber. Of all the manganese mines to which allusion has been made, the position of that of Framura is the most convenient, for it is only half-a-mile from the beach, where it is easy to take the ore, being a continued descent.

Useful as is this mineral in the manufacture of bleaching-powder, &c., its extraction in Italy as a source of wealth is still, I think, an open question, but one well deserving attention.

CHAPTER XIII.

VARIOUS METALLIFEROUS MINERALS.

Arsenic might be procured from pyrites in the vicinity of Pietrasanta. I was informed that it was known there as early as 1566.

Cobalt appears to exist near Seravezza, for M. Angerstein, a Swedish mining engineer, who made a report on the resources of the district in 1751, found a vein near Sta Anna, in the Val di Castello; and Sig. V. Santini, of Pietrasanta, assured me that Cosmo I. had worked it, though I cannot find any record of this circumstance in the books which I have read.

Chrome is very extensively distributed through the serpentine rocks, to which it has, doubtless, communicated the colour; the newer serpentine, or *gabbro verde*, of Liguria, was, in one instance, found by Vauquelin to contain as much as 2 per cent. of chromium. By the decomposition of some of these eruptive rocks this oxide has separated out, and probably produced the chromic minerals, such as chromate of iron, found near Jano (*Pisa*). It is too diffused to have been turned to any account, though I doubt whether it might not be found in large masses by diligent search; certain it is that chromate of iron is generally met with in serpentine.

CHAPTER XIV.

ETRUSCAN METAL-WORK.

With a single exception—some coarse canvas discovered at Volterra—the whole of the Etruscan antiquities with which I am acquainted are made of mineral substances, whether metal, stone, pottery, or frescoes; these throw considerable light on the customs of this ancient people, for of their literature we have no remains. Having drawn from nature a variety of objects illustrating the state of art among the Etruscans, I append some engraved sketches here, as showing what metals they were in the habit of working. Excepting tin and gold, I have no doubt that all the metals employed in the manufacture of these articles were obtained from mines situated in Tuscany; they have, therefore, a direct bearing on this subject.

Before commencing a special description of the engravings, a few cursory remarks on Etruscan art may be acceptable.

The Egyptian forms of the earlier Etruscan alabaster gods, no less point to their intercourse with Africa than the exquisite filagree work introduced by them from Egypt into Italy, where this art seems to have been preserved up to the present time, though, to my mind, the Etruscan ear-ring I have drawn is in no way inferior in point of taste and workmanship to similar productions now made in the manufactories at Genoa. I feel persuaded that we might become far bettter acquainted with the social condition of the Etruscans by a more thorough and thoughtful examination of their works of art. A mere glance at the graceful designs and fine features observable in their statues, leads one to form a very favourable opinion of the Etruscans as compared with the Egyptians. There is more action in their figures; a fine open brow, a handsome nose and well-chiselled mouth, and eyes which bespeak less of the sensuous and more of the intellectual, take the place of that stern fixedness of expression and the hard features so conspicuous in Egyptian types. In Etruria, too, we never find representations of monsters—half-man, half-beast—such as the Egyptian sphinxes. Many other circumstantial evidences might be adduced confirmatory of this remark; thus their mode of writing. In Egypt, mysterious and complicated hieroglyphics were employed, in which, probably, the priesthood and the members of the government were alone skilled, while the masses were entirely ignorant of any method of embodying their thoughts in a material form.

I am well aware that some might object that this was during the infancy of knowledge and art, no better means of writing being yet known, but I would give a conclusive argument against such a theory, since the Israelites remained 430 years in Egypt, and we are acquainted with the simplicity of the characters they employed, so that the Egyptian hierarchy, or, at any rate the government, must have had great dealings with the Jews, at least during the time that they lived in the land of Goshen, and they evidently preferred keeping the lower orders in ignorance and slavery, by enshrouding all knowledge under a veil of difficulty and mystery. In Etruria, on the other hand, we see how, by the simplicity of their alphabet, they early brought the art of writing down to the level of the people. Finding, as we do, coins struck by numerous cities in Etruria, we learn that these possessed somewhat equal rank, incompatible with the idea that the princes who held sway were under a single despot, such as the Pharaohs. The Etruscans were, however, neither socialists nor republicans, for they honoured certain great individuals, statesmen and warriors, and were prouder of perpetuating the memory of their virtues on tombs than were the Greeks, who, more fickle, and divided into numerous factions, could allow an unappreciated Solon to be banished, and witness a Socrates perish before their eyes, in the full vigour of his gigantic mind, without the least remorse. It is, indeed, to the tombs of the Etruscan chiefs that we must have resourse to find their productions, the majority of their best works of art being there deposited, as a grateful memorial to departed worth.

Etruscan art has been divided into three periods, corresponding with contemporaneous phases in their political history.

The *first period* of art in Etruria points to intercourse with Egypt, but it was the Pelasgi from Attica and Arcadia, who, leaving Greece and settling in Etruria, gave the inhabitants the idea of an alphabet and the principles of architecture. The statues and bronze work of this time are characterised by an inferiority of execution, though they exhibit an appreciation of beauty. The eyes are raised obliquely upwards, like those of the Tatars and Egyptians.

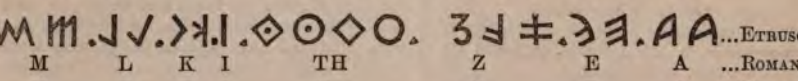
The *second period* was inaugurated about the time of Solomon (B.C. 1000), by the arrival of fresh colonists from Greece. The country became too densely populated, so that the inhabitants divided into two portions. One branch emigrated eastward into Asia; the other remaining in Etruria, along the coasts of the Mediterranean, giving to that country the name of Tyrrhenia. Twelve

cities, each governed by a chief, and collectively placed under an elective king, now rose to greatness and even magnificence, while the arts arrived at a high degree of perfection. The statues made about this time are recognised by their energy of conception and execution. The Etruscans had also a custom of representing their deities with wings, by which we are at once able to distinguish them from the work of all other people.

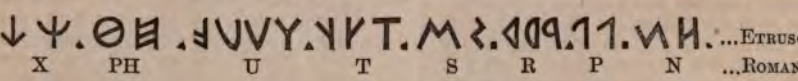
Third period (B.C. 500). Meanwhile the Romans, increasing in power, carried their victorious arms into Etruria, enfeebling the nation, so that a year after the death of Alexander the Great (B.C. 324), it was almost entirely subjugated, and the Etruscan language, after having blended with Latin, rapidly became obsolete. Soon after this (B.C. 280), their last king, Elius Volturrinus, was killed in battle near lake Lucumo, and Etruria was formed into a Roman province.

About B.C. 265, the Romans took Volsinium (Bolsena), a town situated in the Papal States, carrying away 2,000 statues. The influence of Greek art on the Etruscans now became apparent from the great similarity of style and of subjects. Thanks, however, to the Etruscan habit of writing inscriptions on their vases and metal work, we are thus frequently able to distinguish these objects with certainty from Greek productions, when no other clue could be obtained. Some of the finest known specimens of art relating to this epoch are their candelabra, formerly held in very high estimation by the Romans; their lamps, often similar to those of the last-named people, and the beautiful metallic mirrors with engraved groups of figures.

The alphabet of the Etruscans was read from right to left; it is the basis of our own, and as such I may subjoin it for comparison.



	M	L	K	I	TH	Z	E	A	
Roman.	M	L	K	I		Z	E	A	
Greek.	M	Λ	K	I	Θ	Z	E	A	



	X	PH	U	T	S	R	P	N	
Roman.	X			T		R		N	
Greek.	X	Φ	Υ	T	Ϛ	P	Π	N	

H. Aspirate.

Digamma. F.

Explanation of Engravings.

(see next page.)

1. Copper.

A. Cast copper coin of Volterra: *Semissis:* Obverse; double-headed Janus, both young faces (the Roman Janus had one face young, the other old), capped by a *petasus:* reverse, (Felathri) with a club and a crescent moon.

B. Another cast copper coin of Volterra, smaller, *Quadrans;* similar observe: reserve; same inscription, with the club, and three balls denoting its weight. Profile showing the great relief of the coin; upper part rather imperfect, from deficiency of metal.

It is probable that Volterra was founded by the Pelasgi-Tyrrhenians, who established themselves in Eturia. The name Felathri corresponds with that of Elatria, or Elateia (Ἐλατεια), a city of Epirus, whence a great part of the people who occupied Italy migrated, especially the Pelasgi. One of the principal cities of Phocis was called Elatria, and so was another in Thessaly. In a Greek inscription referring to the former of the two, the name is preceded by a digamma, thus FΕΛΑΤΕΙΗ. (Boeckmann; *Inscrip. Græc.*, tom. i., p. 741, pars. iii.), and Millingen (*Considérations sur la Numismatique de l'ancienne Italie*, p. 167).

All the coins in Volterra—of which these are by no means the largest—are copper. This I attribute to the Etruscans having worked the mines of Monte Catini and others in the vicinity; indeed, Mr. Birch confirmed me in my belief, drawing my attention to a similar circumstance with regard to the gold mines of Philippi, since, from the great quantity of the precious metal extracted near that city, we find large gold money coined by Phillip of Macedon. The series of cast copper coins of Volterra, *aes grave*, is very complete; it consists of the—

	oz.		
Dupondis.	24	or 2	*librœ*, with two *obeli.*
As.....	12	,, 1	*libra*, with one *obelus.*
Semissis..	6	,, ½	,, with a crescent moon.
Triens ...	4	,, ⅓	,, with four balls.
Quadrans.	3	,, ¼	,, with three balls.
Sextans...	2	,, ⅙	,, with two balls.
Uncia ...	1	,, 1/12	,, with one ball.

The Etruscans, therefore, employed the

ETRUSCAN METAL WORK.

duodecimal system, and not the decimal. The custom of casting their coins was only adopted by two other Etruscan cities; a few Roman copper coins are also cast.

. Copper ring from Volterra; device, apparently a serpent, the mouth grasping the tail.

. Struck copper coin of Populonia, a city situated near Piombino, (*Grosseto*). Obverse: an owl, symbolising wisdom, standing on two balls, with a crescent moon and two stars; inscription, (Pupluna). Reverse: head of Minerva.

. Stamped copper coin of Populonia; obverse, head of Vulcan: reverse, hammer and tongs, with four balls denoting the weight. Same inscription as preceding.

My reason for selecting an imperfect coin was to illustrate a curious fact, namely, that the Etruscans, at least occasionally, recoined their old money, for on close inspection I perceived that this was stamped over one of the preceding coins. Thus, the moon and two stars may be traced very legibly on the reverse, as well as the circle of dots round the margin. On the obverse, we observe the ball under Minerva's head. Both these coins are of the third period of art.

2. Bronze.

. Bronze candelabrum of the second epoch of art: locally unknown. Shaft supported by a female winged divinity, resting on a tripod with lion's claws; a couchant lion at each angle of the tripod.

The candelabrum is about 18 inches high, and is the only reduced figure on the page; the rest being the natural size. This bronze is an alloy of copper and tin.

3. Electrum.

. Beaten electrum ornament from Vulci; exceedingly ancient and grotesque, and belonging to the first period of art; probably representing a bird with the wing outstretched. It is a thin plate, and is pierced at each corner by a hole for suspending it.

Electrum, the Greek ἤλεκτρον, is an alloy of four-fifths gold and one-fifth silver (Pliny), and is of a paler yellow than ordinary gold. According to some authorities, the word would signify something bright and shining, and is usually connected with ἠλέκτωρ, the sun, to which Homer compares his electron.

4. Gold.

. Gold filigree earring, of the best execution, in style resembling the modern *filigrana* of Genoa; the wire is evidently soldered together in precisely the same manner.

. Gold coin of Populonia; obverse Gorgon's head; beautiful features and exquisite workmanship; reverse, plain, probably struck by a die on a flat anvil, with the tools represented above. Some doubts have been expressed as to whether this was not an ornament, though I do not concur in that opinion, since the following coin is also plain on the reverse—a distinctive peculiarity of much of the Populonian money.

5. Silver.

. Struck silver coin of Populonia: obverse, very grotesque Gorgon's head, with projecting tongue and prominent teeth, and a fillet on the forehead; hair in parallel braids; a row of beads round the margin; two marks (XX) to designate the weight; reverse, plain. The silver was most probably obtained from the argentiferous lead mines of *Cava del piombo*, to which I have referred. Populonia was the only city in Central Italy which had gold coins at this time, except Rome in later times.

6. Lead.

. Cast leaden animal, a lizard (?) from Volterra; evidently sculptured subsequently, as is seen by parallel marks in several places. It is imperfect, but such antiquities are very rare, since lead resists with great difficulty the corrosive action of the carbonic acid present in the atmosphere.

7. Iron.

The Etruscans were famous for their ironwork, as much for their chaste and beautiful bronze castings, so highly prized by the Romans. When Scipio went to the Punic War, he was supplied with iron by the Etruscans of Populonia, who then smelted the specular iron of Rio, as may be seen by the fine particles of ore on the beach near the site of that ancient seaport city.

I regret not to be able at present to figure any Etruscan iron weapons or tools made from Elban iron.

CHAPTER XV.

THE MINERAL FUEL AND OILS OF ITALY.

Italy, possessing as she does such vast mineral resources, it becomes an object of great importance to know whether it is desirable to smelt the ores at home or sell them to foreign capitalists. The answer to this question holds good for iron-works and manufactories in general, and must depend upon the quantity of fuel to be obtained in Italy and neighbouring countries. Could we say positively that there were extensive deposits of coal, as in England, France, Belgium, or Prussia, it would be easy to decide upon the establishment of large works in convenient situations, and to give the necessary impulse to metallurgical operations.

As regards the use of charcoal in smelting-works, it seems to me that it would be very unwise to manufacture it on a large scale, as it would involve the cutting down of the forests; the more so, since the mountainous region of Italy is so subject to violent rains, that wherever the country is stripped of trees all the soil is washed away, rendering the place quite useless for agricultural purposes, and mountain torrents are formed which swell almost instantaneously, carrying away bridges, and devastating the fertile fields towards the plains. Such is the injurious effect of cutting down all the trees, that in such cases the slopes of the soft *macigno* sandstone hills become furrowed by an infinity of little water-courses, forming deep ravines with steep sides, which rapidly enlarge every winter, until at length they often attain a depth of 100 feet. The lower ground at the same time becomes exposed to the severe winter winds, the force of which is no longer broken by the shelter afforded by trees planted on the summits of the hills.

Coal.

Unfortunately, it must be confessed that Italy does not possess any true coal except in the Alps and the Island of Sardinia, and even there only in very insignificant quantities. Meneghini has, indeed, made the important discovery of the presence of the Coal formation in Tuscany, and given an interesting list of the fossil plants, but to the manufacturer this is of no value, for on visiting Jano (*Pisa*), the site of his investigations, I was only able to procure a few specimens of plants, almost converted into anthracite by the metamorphic agency of the neighbouring serpentine eruptions.

The carboniferous formation has been found by General la Marmora to exist in the centre of the island of Sardinia, near the villages of Seni and Perdas de fogu, but it is so broken up by porphyry eruptions, which have converted the coal into anthracite, as to be of no industrial importance, the more so as there are no roads to convey it to the sea.

Lignite.

The Flora at Jano includes *Leptæna*, *Spirifer*, *glaber*, and several other carboniferous brachiopods; besides a numerous flora, characteristic of that period, including such ferns as *Neuropteris rotundifolia*; *Odontopteris schlotheimi*; *Pecopteris arborescens*; *P. acuta*; *P. cyathea*; *P. Bucklandi*; also *Annularia longifolia*, *Lepidodendron* (?) and *Calamites*. Jano still remains the only locality in the Peninsula where carboniferous fossils are found, although Palæozoic rocks have been proved by this discovery to form the greater portion of the Pisan hills, and to constitute considerable strata elsewhere in Tuscany, but now so altered as to have been rendered crystalline, that not a trace of organic remains can now be seen. Though unable to procure any brachiopods at Jano, owing to the fall of a considerable amount of rubbish over the cliff, I found some imperfectly preserved plant remains, the woody parts converted into anthracite; the largest stems I could obtain were an inch thick. They are with difficulty detached, being splintery, and often firmly adhering to the rock. The vegetable structure is indistinct, the trees apparently only individual trunks; in many cases the shales are pervaded with iron pyrites.

Tertiary lignite, on the other hand, occurs in numerous places in Italy, and is often of the best quality to be procured in the world; but the basins in which it is found are very small and insignificant, so that in the course of 20 or 30 years of active working the largest of them might be worked out. This is no reason why these deposits should not be turned to account at once, and become the source of industrial speculation—on the contrary, at a future period there will be greater facilities for obtaining coal from more distant places such as Heraclea and other localities in Asia Minor, as well as from several countries bordering on the Mediterranean, to which Italy must eventually have recourse for her fuel.

The best lignite in Central Italy is that of Montebamboli (*Grosseto*), 13 miles from the coast, and about 65 S. of Leghorn. This mine was opened in 1839, and has been rather extensively worked for many years. It furnishes black lignite of so bituminous a nature

as to be difficult to distinguish from Newcastle coal, to which Prof. Cocchi considers it equal, the more so as it produces excellent coke and abundance of gaseous matter, so that it is suited for a variety of purposes, such as for metallurgical and gas works, and for steam vessels. The French Government have specified it among the varieties of coal allowed to be purchased for the Imperial Navy, and it has been employed for some years at the arsenal of Genoa, which speaks well for its calorific power and purity. M. Ponsard has within the last two years made use of this lignite with success for his new puddling furnaces at the iron works of Follonica (*Grosseto*), but the sulphur it contains renders it unfit for smelting the iron ore.

The basin of Montebamboli is about 3 miles in circuit, and contains two beds, one of 4 feet, below which is another of 2 feet, resting on *Alberese* breccia. They are separated by 3 ft. 4 in. of limestone containing *Dreissena Brardi*. These strata vary in inclination from 0° to 60°; they belong to the Miocene formation, as is seen by the fossil remains, such as exogenous plants, and the presence in the shales of the teeth and jaws of *Anthracotherium*, and the carapaces of tortoises.

The bituminous character of this lignite and its great similarity to coal, result from the intrusion of the serpentine or other eruptive rocks in immediate contact, so that the mineralization of the woody matter, which, under ordinary circumstances, requires a far longer period to bring about, and is only complete in the Palæozoic coal measures, has been here produced in the Middle Tertiary beds. This perfect mineralization is unfortunately accompanied by a great disadvantage, the strata being so broken with faults that it is difficult to work the lignite.

A railway has been made to convey the lignite to the coast at Torre.

Not many miles south of Massa Marittima is the lignite basin of Monte Massi and Tatti (*Grosseto*), in Val di Bruno, where a shaft has lately been sunk. The section of the strata is:—

	Feet.
Clay	63
Lignite	11
Clay	30
Good lignite	3

In some parts there are three beds, of which one is Upper Tertiary, the other two Lower Tertiary. The strata are less broken here than at Montebamboli, but the lignite, although perfectly adapted for glass works, brick works, steam-engines, &c., is less bituminous.

The mine of Sarzanello (*Genoa*) is situated near Sarzana, about 10 miles from Carrara, and 12 from Spezia. It has been worked with considerable activity for several years, as the lignite has been employed at the lead works of Pertusola, on the gulf of Spezia, and also for the steam vessels of the navy. Now that a large arsenal is required at the port of la Spezia, as well as a coaling depôt for steam vessels of the royal and mercantile navies, it is very convenient to possess such excellent lignite so near. There are two beds, the first of 7 inches thick, followed by 6 feet of highly bituminous schists, which undergo spontaneous combustion on exposure to the air, then 6½ feet of good black, resinous-looking lignite.

The first researches at Caniparola (*Massa and Carrara*) were made in 1824, and two years later by Sig. Schneider, of Monte Catini; the mine was shortly afterwards abandoned, to be only resumed in 1857, the present engineer being M. Pirchker.

Prof. Cappelini gave the following section of the strata at Caniparola, in the *Memorie della reale Accademia delle Scienze di Torino*:—

	Feet.	in.
Coarse conglomerate	60	0
Numerous thin alternating beds of clay and conglomerate	262	0
Coarse conglomerate	33	0
Clay, sand, and schistose clay	8	0
Conglomerate	26	0
Clay and *Mollasse*, with vegetable remains	157	0
Dark clay, containing fragments of shells and *Chara Escheri*	0	8
Ash-grey clay	0	4
Blackish argillaceous schists, containing beds of lignite only a few inches thick, except one of 1 mètre (3ft. 4 in.), and another of 30 centim. (1 foot), separated from each other by a thin stratum of schist, so that both can be worked together	20	0
Total	567	0

—(*Serie* II., tom. XIX.)

These strata dip at an angle of 60°, and rest on *Alberese* limestone.

The fossil flora of these beds at Caniparola and Sarzanello is given by Capellini as follows:—

In the clay:—*Juglans acuminata, Chara Escheri, Phylites Sarzanellanus, Sapocites minor.*

In the *Mollasse*:—*Quercus Charpentieri, Fagus attenuatus, Berchemia multinervis, Betula denticulata, Andromeda protogœa, Rhamnus ducalis, Celastrus Capellinii, Cinnamomum Scheuchzeri.*

In both clay and *Mollasse*:—*Sequoia Langsdorfi, Platanus aceroides, Populus leucophylla, Carpinus pyramidalis, Laurus princeps, Oreodaphne Heerii, Hedera Strozzii, Pterocarya Massalongi, Glyptostrobus europœus, Planera Ungheri.*

The most important lignite mine in Piedmont is that of Cadi-Bona, seven miles north

of Savona (*Genoa*), discovered in 1786, and belonging to Marquis Pallavicini. There is only one bed, varying in thickness from 1·50 mètres (4½ feet), to 4·10 mètres (13½ feet), the average being 2·20 mètres (7 feet), with an inclination of 8° or 10° to the north.

1 kilo. produces, by distillation	}	220 lit. of gas.
,, ,,		0·64 kil. of coke.
,, ,,		0·65 kil. of tar.
,, ,,		0·035 kil. of ammoniacal water.

Completely dried it loses 17 per cent. of its weight.

The price on the spot is 15·50 *lire* (12s. 6d.), per ton for the large lumps, and 4·50 *lire* (3s. 7d.) for the small coal.

The new mine of Podernuovo, in Val di Cecina (*Pisa*), is worked on two beds of lignite 1·20 *mètres* (4 feet) in thickness, dipping at an angle of 4° and separated by 1 foot of argillaceous marl, containing *Planorbis*, *Paludina*, and other fresh-water shells; the same clay occurs under the lower bed of lignite.

Marquis Ginori-Lisci has commenced working a mine at Querceto, near Podernuovo (*Pisa*), whence he obtains perfectly black lignite, in which the woody texture has not been destroyed; but the calorific power is far inferior to that of Montebamboli or Tatti. This lignite produces, when struck, the peculiar sound given by charcoal, which it resembles very closely.

An infinity of small lignite basins exist on the east of the Appenines, as in the Provinces of Parma, Modena, Macerata, Forlì, Ravenna, &c.

The lignite of Monte Nerone, near Piobbio (*Pesaro and Urbino*), is many yards thick—it occurs in *Alberese* limestone.

1 kilo. produces, by distillation	}	200 litres of gas.
,, ,,		0·66 kil. of coke.
,, ,,		0·88 kil. fluid bituminous matter.
,, ,,		0·06 kil. ammoniacal water.

without a trace of sulphur.

The specific gravity is 1·17; it loses 6 per cent. of its weight on being dried. The calorific power is stated by Guidi to be 4 : 5 compared with true coal. It has not hitherto been worked.

A great deal of lignite is supposed to exist in this province, both in the Sub-Appenine marls and in the Cretaceous rocks.

Good lignite is mentioned by Prof. Costa as occurring on the Tordino, in Val S. Giovanni, near Teramo (*Abruzzo Ulteriore* I.) In the province of Abruzzo Citeriore on the Adriatic, good lignite occurs at many places, as at Guardiagrele, Pennapiedimonte, Gessopalena, Roccascalegna, &c. Some of the best lignite in the Italian department of the Exhibition is that from Corsoli, in the Abruzzi; unfortunately, it is impossible to judge from a small specimen whether there would be sufficient to render it fit to work. At Baranello (*Molise*), excellent lignite is found in micaceous argillaceous schists. Small lignite basins are abundant in Calabria, as at Gerace, Squillace, Catanzaro, &c.; they are not worked.

Two Eocene lignite basins occur near Iglesias (*Cagliari*), those of Gonnesa and Villamassargia, the former calculated by Sig. Marchese to have an area of 50, the other of 100 square kilometres. There are several beds of lignite in the basin of Gonnesa, in which four mining concessions have been granted, viz., Terras de Collu, Bacu Abis, Fontanamare and Terra Segada. At Terras de Collu a bed of about 2½ feet has been found immediately under a stratum of limestone, which renders it very convenient for working. Two beds, respectively 1ft. 8in., and 2ft. 8in., might be utilized at Bacu Abis. At Fontanamare is a bed of 3ft. 6in., only divided into two by a very thin layer of black clay, and which might be turned to account like the others for local consumption, were it not for the entire absence of road communication.

Of the lignite in Sicily, that of Milazzo (*Messina*), is of very inferior quality; but, by a proper geological examination of the island, it is very probable that many places might furnish lignite of far better quality.

Petroleum.

Petroleum is found in numerous places in Italy, especially in the Appenines. In general it issues between the Pleiocene and Pleistocene strata, and is procured by digging wells, where it floats at the surface of the water, from whence it is removed from time to time. Such artificial pits exist at Montechiaro, near Placenza, Amiano and Fornovo, near Parma, Monte Zibio, Monte Festino and Monte Bonello, near Modena. Brugnatelli estimates the quantity which might be daily procured at Amiano, as 1,500 lbs. At Monte Zibio it is in immediate contact with a lignite bed. At Pietramala (*Florence*) on the southern slope of the Appenines, and close to the road from Bologna to Florence, there is a naphtha spring, known as the *Vulcano*, whence flames issue constantly, and may be seen distinctly at night.

Spontaneous combustion is also observed in the Borra di Cinatti, near Berberino, in Val d'Elsa (*Pisa*). The bituminous calcareous tufa at Querceto (*Sienna*), gave Bechi on distillation 4 per cent. of oil, whence naphtha could be procured by re-distillation.

Carbon	49·1	44·1	32·58	48·1	37·98	35·4	43·45	44·1	50·30
Volatile matter	19·2	23·1	47·28	47·4	44·93	49·1	51·10	44·1	44·70
Ashes	31·4	32·4	20·56	4·1	4·29	15·4	5·15	4·9	1·50
Total	99·1	100·1	100·32	100·1	100·20	99·1	100·10	100·1	100·00
Quantity of coal reduced	27·1	25·1	14·77	28·1		27·71	23·33		24

PRODUCTION OF ANTHRACITE AND LIGNITE IN THE FORMER KINGDOM OF SARDINIA, FROM 1851 TO 1857, IN TONS.

NAME OF MINE.		1851.	1852.	1853.	1854.	1855.	1856.	1857.
Le Cretaz (*Turin*)	Anthracite.	246	184	271	50	40	10	7
Bosco della Goletta (*Turin*)	"	600	40	30	25	20	4	4
Monnello mine, Lanzo (*Turin*)	Lignite.	—	—	—	—	—	74	
Boca (*Novara*)	"	—	—	—	20	40	110	
Bagnasco and Nucetto (*Cuneo*)	"	4,500	2,000	2,000	4,000	4,680	—	
Poggi di Ceva (*Cuneo*)	"	—	—	—	—	—	—	
Casti Bona (*Genoa*)	"	2,000	1,000	3,000	15,000	20,000	24,050	
La Borasina (*Genoa*)	"	—	—	—	—	4	4	
Terras de Collu (*Cagliari*)	"	—	—	—	1,500	—	—	

The inferior qualities of lignite in Italy, though not possessing great calorific power, often contain mineral oils which might be turned to good account by distillation, and return large profits. It need only be mentioned that at Halle, in Prussian Saxony, the manufacture of oil, paraffine, and the valuable series of tar dyes, from Tertiary brown coal, has been carried on of late years with wonderful success, and is daily increasing. What an advantage it would be if the lignite scattered through more than a dozen provinces of Italy, should be employed in the manufacture of oil and candles, which might be as easily and extensively exported to Western Europe as those of Prussia. The Italian Government would do well to give every encouragement to the establishment of such manufactories in Italy, as the high prices at which the products of distillation are sold would permit them to form an important article of export.

Although mineral fuel may not be abundant in Italy, there is no reason why that which she possesses should be neglected. It is a wise Providence which has so arranged that no country, however favoured, should be able to do without others; and while the liberty which Italy now enjoys, and the numerous inducements she has to rouse herself from secular lethargy, all point to the necessity of developing the industrial resources and manufactures of the country, it will be no less imperative to encourage foreign trade in those commodities which, like coal, she does not possess, in exchange for such as she exports.